New Scientist

WEEKLY 7 October 2023

SPECIAL ISSUE

YOU AND YOUR MICROBIOME

Everything you need to know about the microbes that shape your health and happiness

Where do your gut microbes come from and why does it matter?

The surprising role of gut bacteria in chronic conditions

Top tips for keeping your microbiome healthy

The incredible way your friends, family and pets influence your microbiome

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New Scientist Live

Our big show is this weekend! Saturday and Sunday are open to all, and Monday is Schools' Day. Tickets are available online and on the door at ExCeL London. Do come and join us.

newscientist.com/nslmag

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Instant Expert

The quantum world

Does anyone understand quantum theory? The legendary Richard Feynman suggested that if you think you do, you haven't understood it at all. Join six expert speakers in London on 28 October to hear about the coming revolution in quantum technologies. Plus, find out how quantum mechanics plays a deep role in biological processes and sits at the core of our current best theory of the cosmos.

newscientist.com/events

Tour

Dino hunting in the Gobi desert: Mongolia

Join Susannah Maidment, the principal researcher in fossil reptiles at the Natural History Museum, London, on a fossil prospecting and digging expedition to Mongolia. Visit the stunning Flaming Cliffs, site of one of the earliest discoveries of dinosaur eggs in 1923. This 15-day tour starts on 27 August 2024 and costs £7199.

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Podcast

Weekly

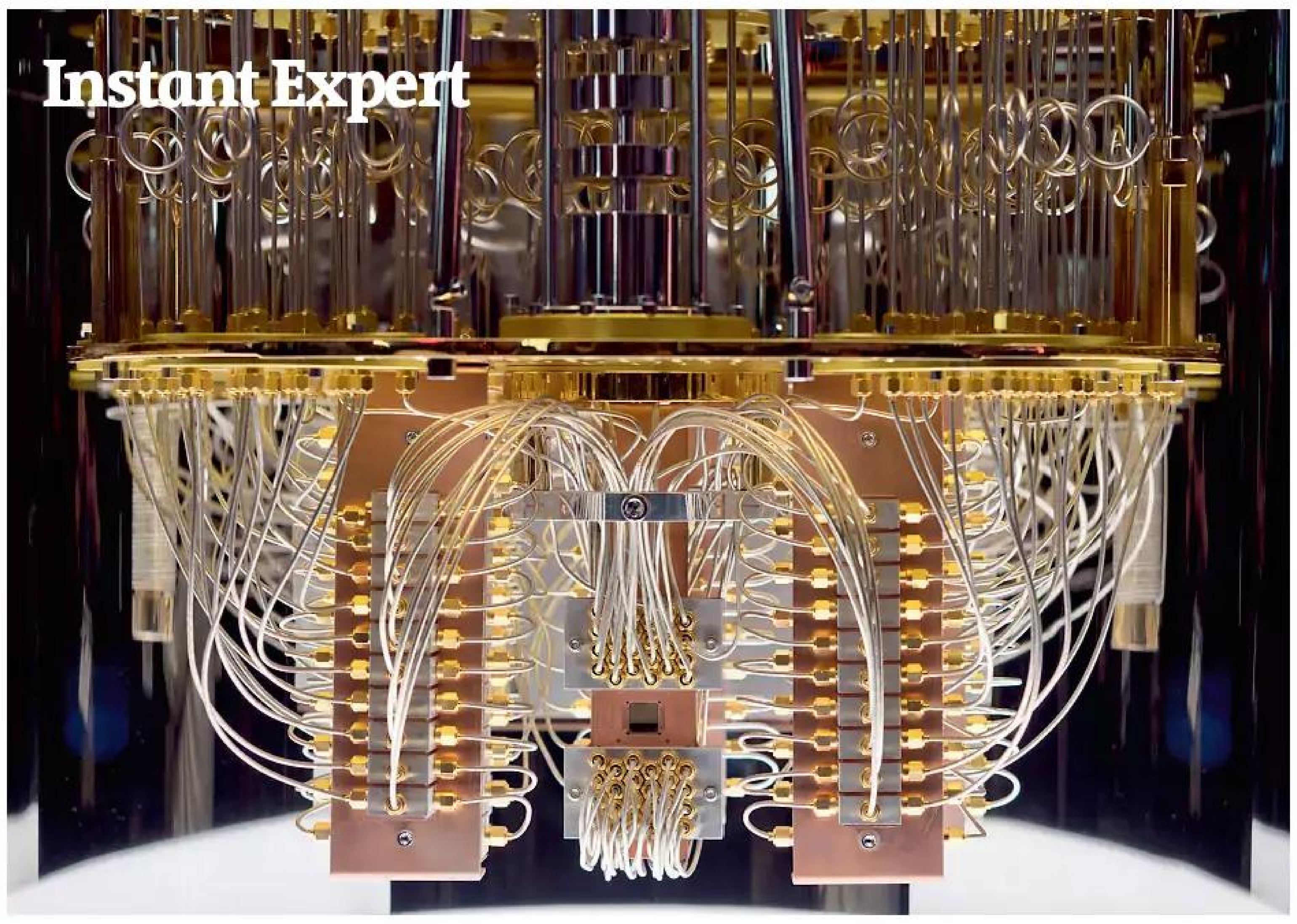
The team take a close look at the covid-era explosion of telehealth start-ups in the US and whether they are failing to meet people's needs. They find out how extreme weather shapes insect populations and learn where to start investing in real estate on the moon. Plus, if antimatter is the opposite of normal matter, does it fall up instead of down? The verdict seems to be in.

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WOLFGANG KAEHLER/LIGHTROCKET VIA GETTY IMAGES

Digging for fossils Discover dinosaur remains in the Gobi desert



BOYKOV/SHUTTERSTOCK

Quantum computer Entanglement powers impressive calculations

Video

Injured mice walk again

Gene therapy has allowed mice with complete spinal cord injuries to walk again. Researchers at NeuroRestore in Switzerland also used "guidance molecules" to direct nerve fibres to their natural destinations and restore neural connections. They hope to combine these tools with electrical stimulation to treat complex spinal cord injuries in humans.

youtube.com/newscientist

Newsletter

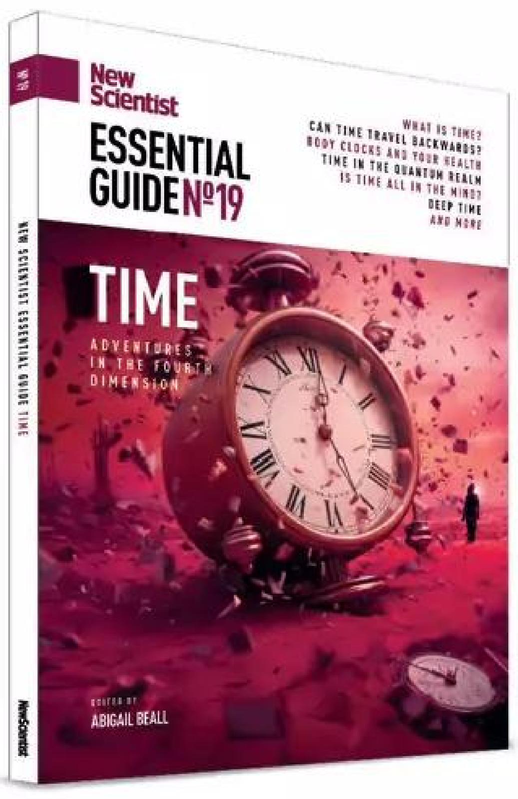
Launchpad

From asteroid Bennu's fresh samples to the launch of a NASA mission to asteroid Psyche, Leah Crane unpacks all the latest space-rock news. Find out how a diverse bunch of comets, dwarf planets and moons – as well as asteroids – are helping us to understand our place in the universe.

newscientist.com/launchpad

Newsletter

"Imagine the solar system as a baked cake. It is impossible to reverse engineer the ingredients"



Essential guide

Our lives are often governed by the familiar ticking of the clock, but where does this ticking come from? This *New Scientist Essential Guide* explores why time is the fundamental facet of our existence. Available to download in the *New Scientist* app or to purchase in print from our shop.

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Trust your gut

Impressive factoids have nothing on the true story of the microbiome

YOU may have heard that your microbiome – the microbes that reside in your gut and elsewhere around your body – outnumber human cells by a whopping 10 to 1. Or that, combined, this incredible mass adds up to as much as 2 kilograms of your body weight. These notions have become widespread over the past few years as scientific and public interest in the microbiome has grown, with much of that interest concerning whether it could be the key to unlocking better health.

But as alluring as they are, these "facts" aren't true – not even close. Your ratio of microbes to cells is more like 1 to 1, and the microbiome weighs a much more modest 500 grams. Have we all got carried away with microbiome-mania?

In this special issue, starting on page 30, we put aside the hyperbolic – albeit catchy – factoids and take a clear-eyed look at what we really do, and don't, know about the multitude of microbes living inside us, with a special focus on the gut.

What is true is that there is much we still don't know – for instance, how to test whether your microbiome is in good health. And when it comes to the products and treatments that promise to give your gut microbes a boost, some claims should be taken with a generous pinch of salt.

> "The microbiome has a hand in everything from our mood to our risk of arthritis"

Even so, as we delve into the research on the communities of bacteria, fungi and viruses that live in us, what we discover is truly amazing. It is increasingly clear that the microbiome has a hand in everything from our mood to our risk of arthritis. There are even hints that gut bacteria may be involved in some of our hardest-to-treat conditions, like Alzheimer's.

Incredibly, our microbiomes are also shaped by those around us, which means the microbiome health of those we live with could be directly influencing our own. In fact, such is its reach in our lives, it is no exaggeration to say that what we are discovering about the microbiome challenges our very understanding of what it means to be human.

So there is no need to stomach the myths. The truth is far more interesting. ■

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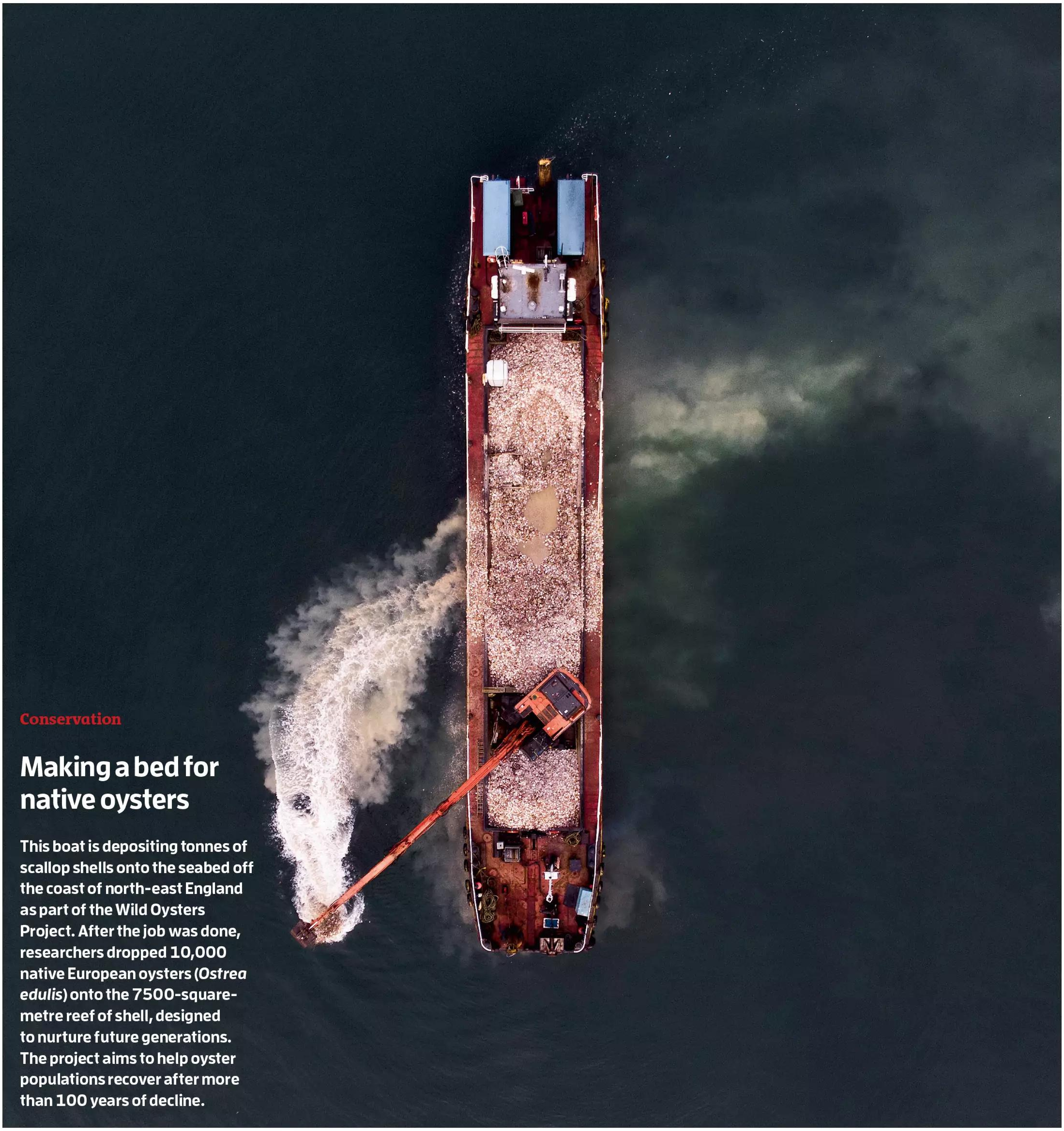
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We finally know what makes orange carrots orange **p17**



Conservation

Making a bed for native oysters

This boat is depositing tonnes of scallop shells onto the seabed off the coast of north-east England as part of the Wild Oysters Project. After the job was done, researchers dropped 10,000 native European oysters (*Ostrea edulis*) onto the 7500-square-metre reef of shell, designed to nurture future generations. The project aims to help oyster populations recover after more than 100 years of decline.

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Environment

Tanker surge raises risk of oil spills

Loss of sea ice means ever more Russian oil tankers are travelling through Arctic waters

Jeremy Hsu

RUSSIA has allowed oil tankers that lack reinforced hulls for dealing with ice to navigate its Arctic waters for the first time – a move that scientists warn could raise the risk of damaging oil spills in the sensitive Arctic ecosystem.

There is already an unprecedented surge in oil tankers travelling eastwards through the Northern Sea Route, which runs along the Russian Arctic coastline to China's ports in the Pacific Ocean. Taking advantage of reduced sea ice caused by climate change, Russia has increased the number of oil shipments to China in response to Western sanctions that cut off access to the European market after Russia invaded Ukraine in March 2022.

"While we only saw one test voyage in 2022, and before that only a handful of oil tankers via the Arctic in the entire decade prior, this summer we have seen in excess of 15 tankers, including large Suezmax vessels without ice classification," says Malte Humpert at *High North News*, an independent newspaper published by the High North Center at Nord University, Norway.

Such oil shipments to China must also pass through the Bering Strait between Russia and Alaska – a "marine mammal superhighway" that represents "one of the most important wildlife migratory choke points in the entire Arctic", says Margaret Williams at the Belfer Center, a think tank at Harvard University.

As the world warms, there is less ice in the Arctic to block the passage of ships



ANDREI STEPANOV/SHUTTERSTOCK

This wildlife includes grey whales and belugas, Pacific walruses, ice seals and more than 10,000 bowhead whales that migrate each year between the north Pacific and Arctic waters, says Williams. Any oil spilled there could affect these species and millions of seabirds, along with local human populations.

"This region has been home to people for thousands of years," says Williams. "And many communities on both sides of the strait – Siberian Yupik, Central Yupik, Iñupiaq and Chukchi – continue to depend on the abundance and health of the marine environment."

Oil spill clean-ups in the Arctic's icy waters could be "nearly impossible, as the oil becomes viscous and will mix with sea ice", says Humpert. The impacts could also last a long time: a study published this month showed slow oil degradation and lingering residue almost 40 years after oil spill experiments at Baffin Island in the Canadian Arctic.

More broadly, Arctic shipping has grown by 7 per cent each year over the past decade, according to a study published this month. The research showed that the amount of time ships spend operating in extreme winter conditions has tripled, largely because there are now more liquefied natural gas and oil projects in the region.

Russia's developing Arctic LNG 2 and Vostok Oil projects could potentially double the volume of oil and gas flowing through the Northern Sea Route within the next few years, says Humpert. He describes that trend as "bad news for the Arctic environment". ∎

Zoology

Beetles raise their young in food waste left by army ants

THE piles of food waste left by raiding army ants serve as nurseries for numerous beetle species.

Army ants forage in mass raids. Insects and other arthropods caught up in the tide are killed and consumed back at the "bivouac", a dense ball of living ants that serves as a temporary nest. There, prey fragments and dead ants accumulate, so when the army moves on, it leaves behind a food waste pile, or midden, roughly the width of a dinner plate.

Now, Daniel Kronauer at the Rockefeller University in New York and his colleagues have collected more than 30 middens from 13 different *Eciton* army ant colonies in the rainforests at La Selva Biological Station in Costa Rica. The researchers found more than 8000 adult beetles, some 500 beetle larvae and two dozen eggs. One midden alone carried 2705 individual beetles.

By analysing DNA and the physical features of the beetles, the researchers identified 91 different beetle species living in the refuse piles. The team even described two species that were new to science.

The researchers frequently saw beetles mating in the middens – and for 22 beetle species, they found both adults and larvae. The larvae may have been hatching from eggs in the waste heaps or crawling in from nearby (*Ecology and Evolution*, doi.org/kwn3).

"It appears likely that the middens play a crucial role in completing the life cycle of these beetles," says team member Christoph von Beeren at the Technical University of Darmstadt in Germany.

> "It appears likely that the food dumps play a crucial role in completing the life cycle of these beetles"

The findings underscore "the role of army ant colonies as promoters of biodiversity in tropical rainforests", says von Beeren. Army ant hangers-on also include "species that participate in army ant swarm raids, including antbirds, butterflies that feed on the birds' droppings, flies and parasitic wasps", says von Beeren. ∎

Jake Buehler

Health

Frequent cannabis use may raise the risk of heart attack

Grace Wade

PEOPLE with cannabis use disorder have an increased risk of heart attack, stroke and other major cardiovascular conditions, suggesting that frequent cannabis use may impair heart health.

Anees Bahji at the University of Calgary in Canada and his colleagues analysed the health records of 59,528 people living in Canada. Half had been diagnosed with cannabis use disorder – when someone uses marijuana despite it disrupting their life – between January 2012 and December 2019. The researchers tracked who had a heart attack, stroke or other major cardiovascular condition in this period.

After adjusting for factors such as age, gender and socioeconomic status, the researchers found that people with cannabis use disorder had a nearly 60 per cent higher risk of developing a cardiovascular condition than people without it. The risk worsened with the severity of the disorder. People who sought care for cannabis dependence five or more times were more than twice as likely to later have a heart or vascular problem than people without cannabis use disorder, for example (*Addiction*, doi.org/kwn4).

The findings suggest frequent cannabis use harms heart health, although the mechanism behind the association is unclear, says Bahji. It may be due to compounds in the drug, such as tetrahydrocannabinol, or THC, binding to receptors in the body. This can elevate heart rate, decrease blood pressure and affect blood clotting, he says.

However, many people use cannabis infrequently. "I would really like to see studies looking at how lower levels and short durations of cannabis use relate to heart health," says Jennifer Bailey at the University of Washington, Seattle. "Or whether different cannabis products are differently related."

Space

Astronomers alarmed by satellite that outshines all but seven stars

Alex Wilkins

A PROTOTYPE satellite for a proposed space-based mobile phone network is brighter than all but seven stars in the night sky. The satellite and others like it could force ground-based telescopes to either track and dodge satellite trails or prolong their observations to gather enough unspoilt data.

In 2022, Texas-based firm AST SpaceMobile put its BlueWalker 3 satellite into orbit to test the feasibility of a mobile phone network orchestrated from space. Early observations of BlueWalker 3's 64-square-metre reflective antenna suggested it was brighter than most stars in the sky.

That has now been confirmed by a year-long monitoring campaign using telescopes in the US, Chile, the Netherlands and New Zealand. Siegfried Eggl at the International Astronomical Union in France and his colleagues have found that BlueWalker 3 is more brilliant than previous measurements indicated, having a similar brightness to the brightest stars in the constellations Canis Minor and Eridanus (*Nature*, doi.org/kwpw).

This presents a significant threat to ground-based astronomy, says Eggl,

2022

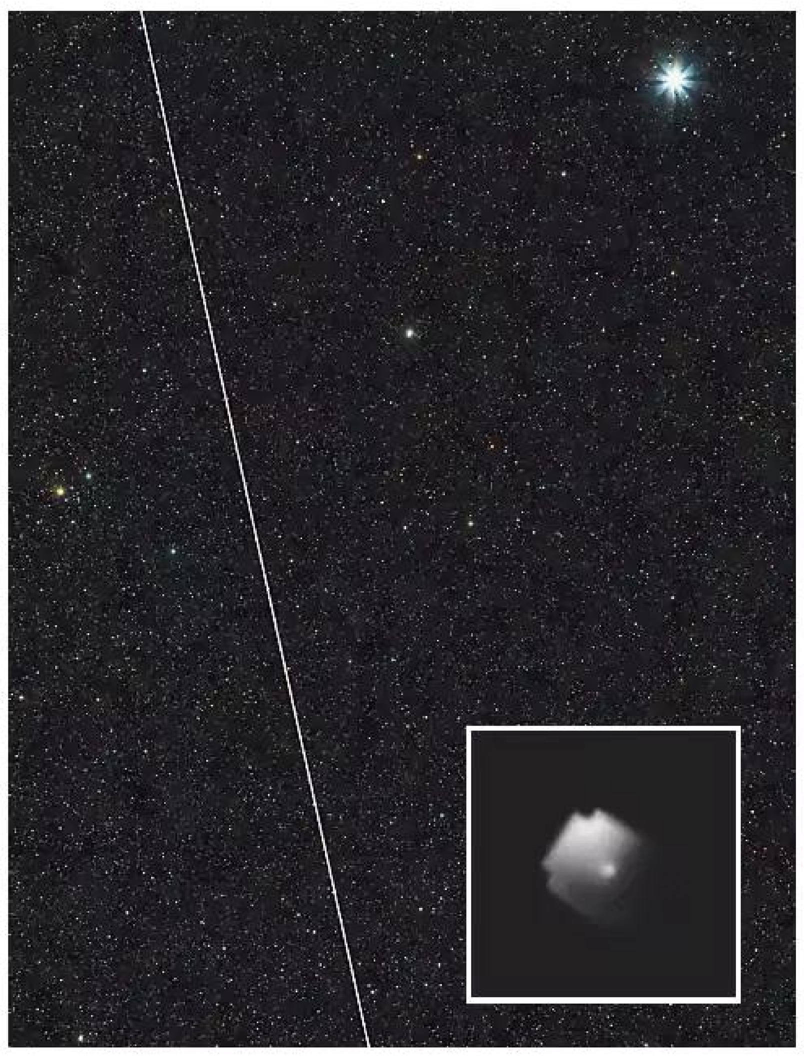
When AST SpaceMobile put the BlueWalker 3 satellite into orbit

64

The size in square metres of the satellite's reflective antenna

90

Number of next-gen satellites planned by AST SpaceMobile


A. BLOCK/IAU CPS; INSET: MICHAEL TZUKRAN

Trail of the BlueWalker 3 satellite across the night sky, taken from a backyard in Tucson, Arizona. Inset: the satellite itself

especially for wide-angle surveys of the night sky, such as one that will be carried out at the Vera C. Rubin Observatory in Chile. "If there's a bunch of these really bright objects, I think the danger is that there's going to be potential large-scale data loss, if not damage to detectors, if that's not mitigated," he says.

Some of this might be avoided if telescopes adopt tracking and avoidance strategies, but these can still fail because satellites are hard to track. It might mean telescopes would need to periodically shut down while a satellite crosses their line of sight, potentially delaying observations or skewing datasets.

Eggl and his team also found that BlueWalker 3's brightness fluctuated, depending on the attitude, or angle, at which it faced the sun. Companies like AST SpaceMobile have control over this angle, so they play a significant role in making sure that the satellite reflects minimal light, says Eggl.

In a statement, an AST SpaceMobile spokesperson said it is "collaborating with NASA and certain astronomy working groups to develop advanced industry solutions, including potential operational interventions". It is also avoiding broadcasts in areas sensitive to radio astronomy, the spokesperson said, as well as controlling the satellite's attitude to minimise brightness and developing anti-reflective coatings for its next generation of satellites, which it says will number around 90.

More observations are needed to understand the full impact these satellites may have on astronomy, especially for longer wavelengths of light, such as the radio band. Satellites like BlueWalker 3 are equipped with powerful radio transmitters, so they have the potential to do more damage to radio-based astronomy, says Eggl. "For optical light, these things are as bright as the stars in the sky, but for radio astronomy, they can be as bright as the sun," he says.

Comprehensive observation projects like this are essential, says Aparna Venkatesan at the University of San Francisco, California, because "an individual satellite's brightness is a complex, time-varying function of its design, area, viewing angle and altitude".

"With ever more satellite launches planned by a rapidly rising number of state and private space actors, we must now consider not only the light pollution and electromagnetic interference from a diverse range of individual satellites, but the aggregate effects of all the satellite constellations slated for low Earth orbit," she says.

Health

mRNA work wins medicine Nobel

Nobel prize awarded to researchers whose insights were crucial to developing covid-19 vaccines

Clare Wilson

TWO scientists whose work led to the mRNA vaccines against covid-19 have been awarded the 2023 Nobel prize in physiology or medicine. Katalin Karikó and Drew Weissman received the award for their research on chemically changing strands of mRNA, which made it possible to use them in vaccines.

The technology was licensed by US biotech firm Moderna, as well as German company BioNTech – where Karikó was working at the time – which then collaborated with the multinational firm Pfizer. This led to the Moderna and Pfizer/BioNTech vaccines, two of the main covid-19 vaccines used in high-income countries.

mRNA is a "messenger" molecule that allows genetic information stored in DNA, in the cell nucleus, to be transported to protein-making factories called ribosomes elsewhere in the cell.

There had long been interest in using mRNA medically to instruct human cells to manufacture proteins that they wouldn't normally make. But if artificially synthesised mRNA is injected into the body, it looks similar to mRNA produced by bacteria – and so is destroyed by various immune chemicals.

While at the University of Pennsylvania in the 1990s, Karikó and Weissman worked out a way to chemically tweak synthesised mRNA so that it looks like the version naturally made by mammalian cells – and so avoid the immune attack.

In the covid-19 vaccine, the mRNA contains instructions for making the coronavirus spike protein, a molecule on the outside of virus particles. When someone is given the vaccine, their cells start to make this protein, which triggers a normal immune response.

The Moderna and Pfizer/BioNTech vaccines were widely rolled out in high-income countries from early 2021 onwards. Initially, they were very successful at stopping people from being infected with covid-19.

They aren't as good at preventing infections with sublineages of the omicron variant of the virus, which began spreading in late 2021. However, the vaccines are still effective at reducing illness severity and averting deaths.

The mRNA covid-19 vaccines helped prevent countless deaths and severe ill health from the coronavirus and enabled societies to open up again, said Thomas Perlmann, the secretary of the Nobel Committee for Physiology or Medicine, at an announcement on 2 October. "The work had a major impact on society during the recent pandemic."

Another advantage of mRNA technology is that it allows vaccines to be made more quickly against any new viruses, such as a bird flu pandemic, said Perlmann. "Future vaccines based on mRNA have the potential to become scalable, fast and flexible."

Personalised mRNA vaccines are also being investigated as potential treatments for cancer. ▮

Katalin Karikó and Drew Weissman have won the 2023 Nobel prize for medicine



JONATHAN NACKSTRAND/AFP VIA GETTY IMAGES

Physics

Physics Nobel goes to trio who sliced up time with light

THE 2023 Nobel prize in physics has been awarded to Pierre Agostini, Ferenc Krausz and Anne L'Huillier for their work on using ultra-short pulses of light to study electrons.

Anne L'Huillier at Lund University in Sweden, only the fifth woman to have won the physics Nobel, heard the news while midway through teaching. "The last half hour of my lecture was a bit difficult to do," she told a press conference on 3 October.

Just as we use light to observe the world around us, it can be used to probe the subatomic world. But because particles such as electrons can move faster than the duration of a pulse of light, many subtle details of their movement can be lost.

That is why "attosecond" light pulses – which last about a billionth of a billionth of a second – have proved so vital. The first key breakthrough in producing them came in 1987, when L'Huillier and her colleagues discovered that light from an infrared laser shone through neon, argon or xenon gas contained unusually short bursts of constant intensity. She and her team described this effect mathematically.

In 2001, Pierre Agostini at Ohio State University and Ferenc Krausz at the Max Planck Institute of Quantum Optics in Germany independently developed techniques based on L'Huillier's work to more finely generate and control these attosecond pulses.

Agostini's and Krausz's methods have frequently been used to study how electrons move together over tiny distances and how their quantum properties, such as their spin, change depending on the material they are in.

Such work has led to advances in ultra-fast electronics, which could one day result in the development of more powerful computer chips. It has also let us distinguish molecules from each other based on their electron properties, which could be used for fast and accurate diagnostic techniques, such as certain kinds of blood test. ▮

Alex Wilkins

"Anne L'Huillier heard that she had won the Nobel prize while midway through teaching"

Zoology

Tiny crocodile can moo and that may help us track it

Sofia Quaglia

THE sounds some crocodiles make could help conservationists keep tabs on species that are otherwise hard to monitor.

The African dwarf crocodile (*Osteolaemus tetraspis*) prowls the forests and streams of West Africa. But the species, which typically reaches about 1.5 metres in length, is hard to spot and difficult to count.



MILAN ZYGMUNT/SHUTTERSTOCK

African dwarf crocodiles make some distinctive sounds, including moos, rumbles and "gusts"

"It's a species that really nobody knows about," says Agata Staniewicz at the Adam Mickiewicz University, Poland.

To see if listening to the sounds the crocodiles make could provide information, Staniewicz and her colleagues recorded 97 vocal signals from a pair of *O. tetraspis* at Bristol Zoo Gardens in the UK. The recordings revealed that the species produces vocal "drums", "rumbles" and strange "gusts" that sound like a howling wind.

"These lower-frequency sounds, you can kind of hear them as sort of pulses, and they're barely on the range of human hearing," says Staniewicz.

The tiny crocodiles also produce a sound uncannily reminiscent of a cow's moo (*African Journal of Herpetology*, doi.org/kwnx).

The researchers then compared the 97 vocal signals to 201 mystery sounds that had been recorded during an elephant conservation project in Gabon. The analysis confirmed that the unidentified sounds came from *O. tetraspis*.

This means conservationists may be able to track the crocodiles using microphones, says Staniewicz. ▮

Technology

Plastic can be recycled into hydrogen fuel and graphene

Alex Wilkins

A NEW way to make hydrogen from waste plastic produces graphene as a byproduct. If the graphene is sold at a fraction of its current price, it could be profitable enough to generate hydrogen as a clean fuel.

The most common way to produce hydrogen involves reacting steam with methane sourced from natural gas. However, this process releases a lot of carbon dioxide. There are carbon-free ways to make hydrogen, but they require large amounts of electricity and can be expensive in places where energy costs are high.

Now, James Tour at Rice University in Houston, Texas, and his colleagues have found a low-cost way to produce hydrogen without releasing CO_2 by rapidly heating household waste plastics.

As well as producing hydrogen, the process makes high-quality, commercially viable graphene. Tour and his team calculated that selling the graphene at even 5 per cent of its current market value would mean the hydrogen costs nothing to produce. "Even at that price, we're making like $4.30 per kilo on hydrogen, so now hydrogen becomes free," says Tour. "Your fuel is free while you're cleaning up the world."

Polyethylene, used in plastic bags, can be converted into hydrogen



JENYA SMYK/SHUTTERSTOCK

The process works by repeatedly passing electricity through a sample of waste plastics mixed with a conductive material, heating the plastics to around 2800°C in about 4 seconds. The researchers used waste polyethylene, which makes up about 34 per cent of all plastics and is the most common plastic in the world, as their test material.

The rapid heating causes the polyethylene's carbon atoms to bind into graphene. The process also gives off a mix of gases: 92 per cent pure hydrogen, and the remaining 8 per cent a variety of carbon-based compounds like methane and propane (*Advanced Materials*, doi.org/gsqm7x).

While these byproducts could be sold on their own, Tour and his team found that hotter and faster heating produced more graphene and hydrogen with fewer residual compounds.

Once locked into graphene, the carbon is very unlikely to enter Earth's atmosphere as CO_2 again, says Tour.

"Even selling graphene at only 5 per cent of its value, the hydrogen costs nothing to make"

"We know that because we have graphite in the world. If microbes could eat graphite or graphene, which is single sheets of graphite, we wouldn't have any graphite in the world. But we have graphite mines – it doesn't decompose rapidly."

Tour's team has only shown that the method is viable in the lab so far. But a separate company co-founded by Tour called Universal Matter has used the same heating method to produce graphene commercially. "You could have a smaller-scale deployment for generating hydrogen certainly within five years," says Tour. "You could have a large-scale deployment within 10."

Producing hydrogen this way could form a part of a future circular economy, says Upul Wijayantha at Cranfield University, UK. But scientists will need to solve some technical challenges before it can be deployed on an industrial scale, he says. "We don't know, beyond the lab scale, what kind of challenges they will encounter when they handle a massive scale of plastics, gas mixtures and byproducts, like graphene." ▮

New Scientist Live
The future of transport
See Sarah Sharples at New Scientist Live on 7 October
newscientist.com/nslmag

Climate change

Can China turn the world green?

As the world's biggest carbon emitter and the largest producer of clean energy tech, China is crucial to our climate future, reports **James Dinneen**

THERE is a question frequently repeated by sceptics of plans to cut greenhouse gas emissions in Western nations: what about China? This simplistic refrain asks the right question for the wrong reasons. That is because China plays a paradoxical role in the global picture of climate change. It is now by far the largest emitter of greenhouse gases, annually pumping out more than the combined emissions of the 38 states in the OECD group of advanced economies. It is also the world's largest builder and supplier of clean energy technologies that are key to cutting those emissions.

As the transition away from fossil fuels proceeds, the Chinese government has increasingly used this status for geopolitical leverage, positioning the country to play an ever more dominant role in the 21st century and shaping global progress on climate change – for better or worse.

Its path to becoming a green superpower has multiple stages, starting with the energy transition within its own borders. "The scale of clean energy investment is without parallel," says Lauri Myllyvirta at the Centre for Research on Energy and Clean Air in Finland. "We exhausted all superlatives a couple of years ago."

In 2023, which will be a record year for global development of renewable energy, more than half of all new wind and solar capacity is set to be installed in China. It is also adding more new nuclear power and hydropower than anywhere else, and in August overtook Europe as the largest builder of offshore wind. In June, two years ahead of schedule, fossil fuels made up less than half of China's electricity generating capacity, though coal remains a big and growing part of its energy mix (see "The coal question", right).



TONY SHI PHOTOGRAPHY/GETTY IMAGES

China's energy use makes it the world's largest carbon emitter

2030
China said its carbon emissions would peak by this year

$1tn
Spending by China on overseas infrastructure since 2013

80%
Proportion of global solar panels manufactured in China

China boasts record adoption of electric vehicles too, with these making up more than a fifth of all new vehicles sold in China in 2022, as well as the world's largest high-speed train system. A general economic malaise has also created a "tail wind" for its emissions reductions, says Myllyvirta.

All of this gives observers confidence that China will, at the very least, be able to meet its near-term target of reaching peak carbon dioxide emissions by 2030 or earlier. "Those are going to be snowballs rolling by themselves," says Li Shuo at Greenpeace East Asia. One report from Norwegian research firm Rystad Energy has even projected that China's emissions from burning fossil fuels could peak as soon as this year, and fall 10 per cent by 2030.

By aggressively growing its own clean energy, China has also reduced costs everywhere else. "They've done the world a huge favour," says Philip Andrews-Speed at the Oxford Institute for Energy Studies, UK. It is largely thanks to those falling costs that new onshore wind and solar facilities are now more cost effective than new fossil fuel capacity in much of the world. That, in turn, has made China the dominant supplier of much of the world's solar panels, wind turbine parts, batteries and the minerals with which all of these are made.

"The scale of clean energy investment by China is without parallel. We've exhausted all superlatives"

For instance, China now makes at least 80 per cent of the world's solar panels and counting. The first half of this year saw panel exports from China increase by more than a third compared with the same period in 2022, according to a report from UK energy think tank Ember, to a total of 114 gigawatts of generating capacity – equivalent to all the solar capacity currently installed in the US (see "Sunny outlook", page 14).

Overseas investment

In addition, China has increasingly invested directly in clean energy overseas. Since the launch of its Belt and Road Initiative in 2013, it has spent just over $1 trillion on various infrastructure projects in nearly 150 countries, including hundreds of billions for oil and gas or coal-related projects. But the nation now appears to be greening these investments. According to a recent report from researchers at Fudan University in Shanghai, China, around half of the $12.3 billion the country has spent on foreign energy in 2023 went to clean energy, ranging from hydropower in Pakistan to a giant floating solar farm in Zimbabwe.

Although the overall amount

was lower than previous years (see "Green investment", page 14), that makes China's outlays this year the greenest of the past decade.

China's green power influence is particularly being felt in lower-income countries. For instance, it recently signed an agreement with South Africa to supply it with more solar panels as well as upgrade an ageing nuclear plant and coal plant. According to Ember, while China exports most of its solar panels to Europe, sales to Africa have increased this year by nearly 200 per cent and exports to the Middle East jumped 64 per cent. A notable exception was a 76 per cent decline in exports to India, which has prioritised its own domestic solar manufacturing.

China also has a growing role in directly financing environmental efforts in lower-income nations, beyond spending through the Belt and Road Initiative. In 2016, it pledged $3.1 billion for climate-related projects in such places, though according to a report from climate think tank E3G, it has delivered just 10 per cent of that so far. Calls for more spending by China – which hasn't joined other large economies in committing to contribute to a $100 billion fund to pay for climate-related "loss and damage" – are expected at the upcoming COP28 climate summit.

China's clean energy dominance has spurred its competitors to try to catch up. In the US, the Biden administration's Inflation Reduction Act, which put hundreds of billions of dollars towards clean energy development, was shaped by a desire to establish domestic industries that are less dependent on China.


ORIENTFOOTAGE/GETTY IMAGES

China's Baihetan dam is the world's second largest hydropower plant

One reason for doing so is concern about embargoes on key technologies or materials, such as China's recently enacted export restrictions on gallium and germanium, two key minerals for advanced electronics. This type of manoeuvre has invited energy experts to make comparisons with the powerful oil exporters of OPEC, who can influence the global economy by deciding to produce more or less oil.

Mineral influence

"In this critical minerals context, we are up against a dominant supplier that is willing to weaponise market power for political gain," said US energy secretary Jennifer Granholm at an International Energy Agency meeting on 28 September, in comments widely interpreted as a reference to China's dominance.

But Edmund Downie at Princeton University says that control of clean energy supply chains wouldn't offer as much geopolitical leverage as control of oil. Unlike an oil embargo, export controls on clean energy technology or minerals wouldn't be felt immediately in the same way as fuel pumps drying up, and other countries would

The coal question

Why is China building so many new coal power plants? The common explanation is energy security, a long-standing concern in China that escalated to a crisis following a series of severe blackouts in 2021 and 2022. These were driven both by drought reducing the amount of available hydropower and heatwaves raising demand for electricity for air conditioning. China doesn't have much oil or gas, but it has abundant coal to fall back on.

Another explanation is that the coal plants can help back up the growing amount of intermittent wind and solar resources on the grid. In that case, if the power stations are used less even as more are built, emissions from coal could fall, despite there being more plants, says David Fishman at the Lantau Group, a Hong Kong-based energy consultancy. "This is China," he says. "They can build a plant and not run it as much as they need."

However, China's existing coal power would be sufficient for both those purposes, says Lauri Myllyvirta at the Centre for Research on Energy and Clean Air in Finland. He says the plants are only operated at half capacity on average, largely because China's electricity market is run in a rigid and centrally controlled way, with decisions about buying and selling power decided by administrators rather than market prices.

Despite some signs of reform, that has big consequences for emissions. A recent paper from Johannes Urpelainen at Johns Hopkins University in Maryland and his colleagues found the resulting inefficient decisions around producing and buying electricity between 2011 and 2019 were responsible for more emissions than India's total over the same period. "China is moving slower than it should and we are going to pay a price for that," says Urpelainen.

There have been efforts at reform, but they have been sedate and incomplete. Myllyvirta puts this down to pushback from entrenched interests among provincial governments and power producers. "When you change the rules, some people win, some people lose," he says.

An even less benign explanation is that coal producers want to get in while they still can, says Li Shuo at Greenpeace East Asia. In a 2021 speech, China's president, Xi Jinping, said its coal use would peak in 2025. Li says coal developers are rushing to build as much as possible before the peak arrives. "Got to make sure you get on the last train," he says.

have more time to respond by expanding their own manufacturing capacity. Unlike OPEC, China is also the main consumer of all the clean technology it makes.

But unease about China's clean power dominance is exacerbated by the nation's slower targets on cutting emissions relative to Western countries, a key source of the "What about China?" sentiment. While the US and the European Union have pledged to substantially cut emissions by 2030, China is aiming only to peak emissions by 2030 and achieve carbon neutrality by 2060. China's leaders have said the country's official status at the UN as a "developing" nation, as well as its smaller share of historical emissions, justifies the delayed

"We are up against a dominant supplier willing to weaponise market power for political gain"

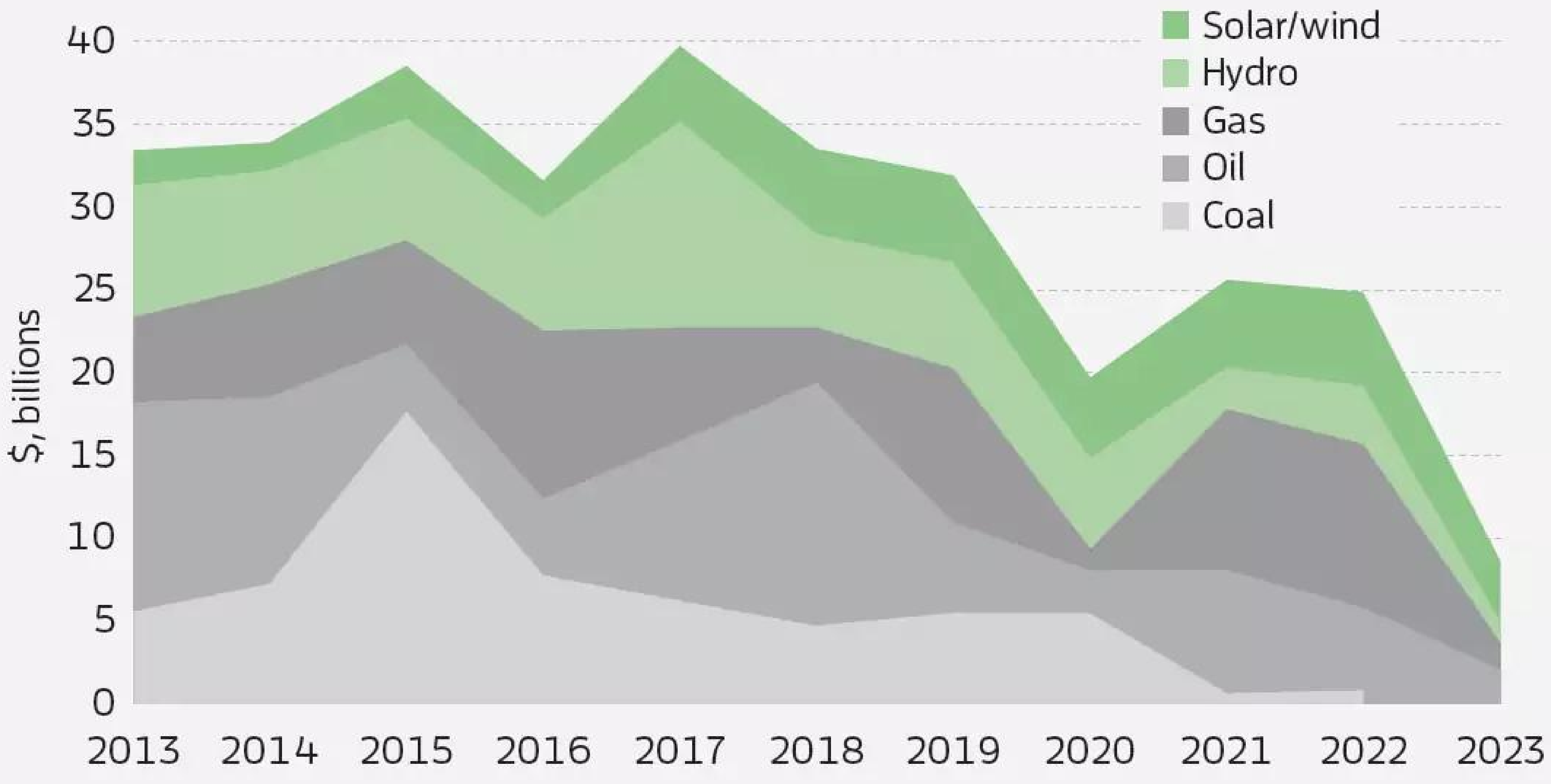
cuts – its per-capita emissions are also lower than those in some other leading economies.

But many have argued China could move faster. US climate envoy John Kerry did just that during a visit to Beijing in July to discuss how the two superpowers might work together on climate change despite growing hostilities. During the visit, China's president, Xi Jinping, said in a pointed speech that the country's path to decarbonise "must be determined by ourselves, and will never be influenced by others".

A major sticking point is China's ongoing expansion of coal power, which is responsible for most of its emissions. One recent report from Global Energy Monitor found there are currently 243 gigawatts of coal power under construction or permitted in China, more

Green investment

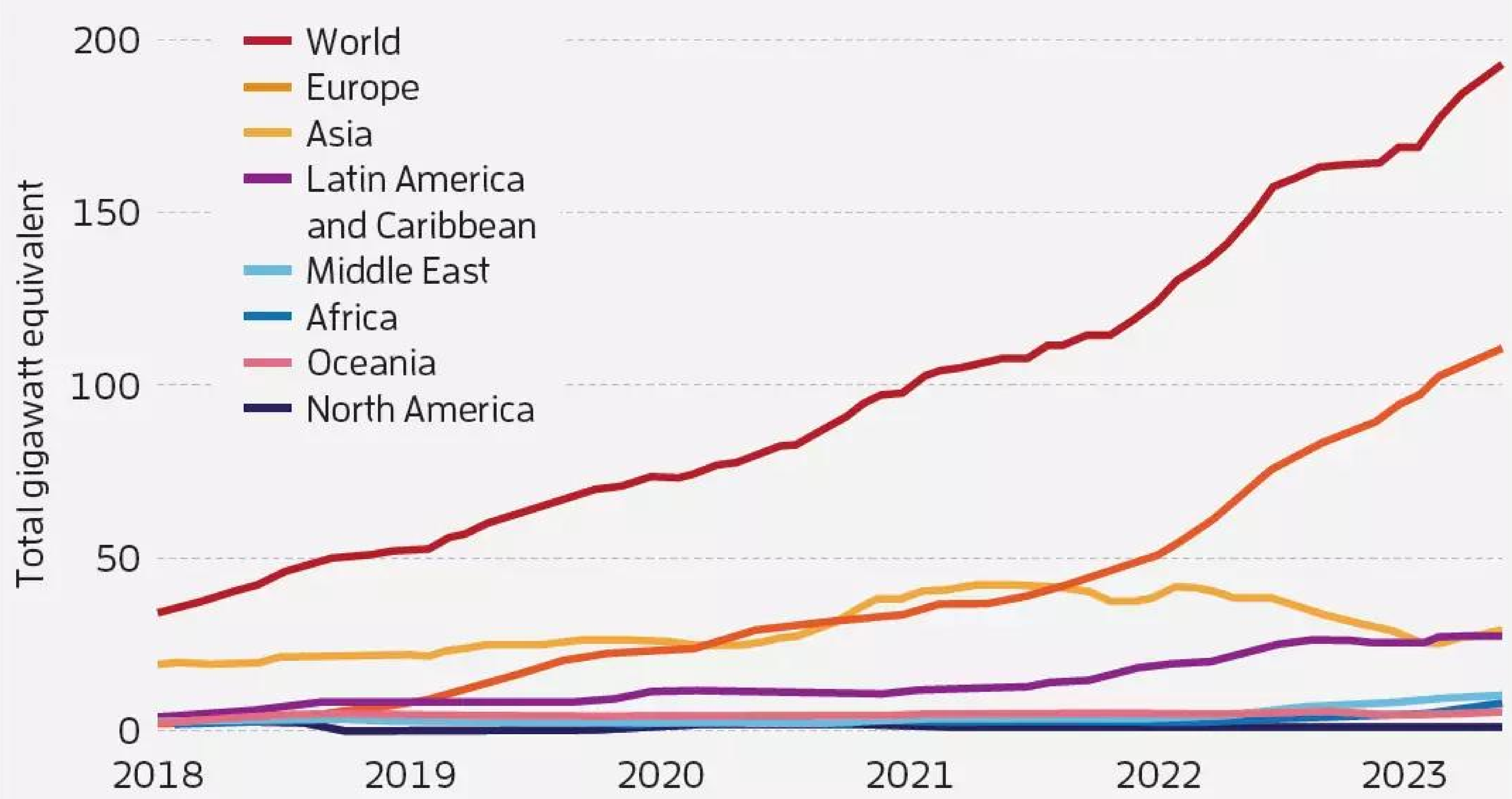
China's public investments in overseas energy projects have shifted away from fossil fuels



GREEN FINANCE & DEVELOPMENT CENTER, FUDAN UNIVERSITY

Sunny outlook

China's solar panel exports are rising rapidly, particularly in Europe



EMBER



A panda-shaped solar farm in Shanxi province, China

VISUAL CHINA GROUP VIA GETTY IMAGES

than the total capacity of current US coal plants. This boom isn't necessarily incompatible with China's official climate targets, but researchers say it is still a disaster for the climate. "There is no way to defend the current coal expansion," says Li at Greenpeace.

Challenges remain

The country's later carbon-neutral target date of 2060 may also be a tacit acknowledgement of the true difficulty of fully decarbonising. One big challenge, beyond the sheer scale of China's current emissions, is that a large share of them come from difficult-to-decarbonise heavy industries. In 2020, emissions from China's steel and cement sectors alone were greater than the European Union's total annual emissions.

A shift to a less energy intensive economy with less construction and large-scale infrastructure could help here, says Myllyvirta, but lots will remain to be done. Official reports on China's long-term decarbonisation strategy describe the need for expanded use of green hydrogen, as well as unproven carbon capture and storage and other technologies, including geoengineering. Success here isn't guaranteed.

And yet, China seems to be well-positioned to gain ever more influence as its energy transition accelerates, regardless of what happens with its own or overall emissions. Andrews-Speed says, assuming there isn't a major event that isolates or destabilises China, such as a war with Taiwan, he sees a future in which its clean energy dominance comes to resemble the reach of the US oil industry after the second world war. Just as that influence shaped the 20th century globally, so too could China's green dominance shape this century. ■

New Scientist Live
Ultra-processed people
See Chris van Tulleken at New Scientist Live on 8 October
newscientist.com/nslmag

Health

Ultra-processed food isn't always unhealthy, say UK food officials

Clare Wilson

UK SAFETY advisers have dismissed concerns that highly processed food, also known as ultra-processed food (UPF), is automatically unhealthy because of the way it is made or its artificial ingredients.

The current way that the UK and most other countries assess the nutritional value of foods – which is generally by how much fat, salt, sugar and calories they contain – remains the best approach for achieving a healthy diet, said a panel of scientists at a press conference on 27 September.

They also warned that people who cut out all ultra-processed foods could make their diets more unhealthy, for instance if they avoid foods such as yogurts, low-fat spreads and wholemeal breads and cereals. "We need to be driven by the science and not have this knee-jerk reaction that treats [all UPF] the same," said Robin May, chief scientific adviser at the UK's Food Standards Agency.

Concerns about processed foods have been growing, but it is unclear if there is something uniquely bad about them or if they just tend to be higher in things like fat and sugar. The issue has come into focus this year after Chris van Tulleken, a doctor and TV presenter, published a book called *Ultra-Processed People: Why do we all eat stuff that isn't food... and why can't we stop?*

Van Tulleken has called for more countries to adopt dietary guidelines pioneered in Brazil, where people are advised to prioritise eating whole foods and homemade meals, and avoid eating factory-made foods.

Doughnuts are rich in fat and sugar as well as being ultra-processed



NEIL LOCKHART/ALAMY

On 27 September, at a press conference held by the UK's Science Media Centre, researchers from nutrition organisations rejected the proposed system. "We absolutely need foods to be processed so that we can feed the world," said Janet Cade at the University of Leeds, UK, who is a member of the British Nutrition Foundation.

May said UPF includes products that are both healthy and unhealthy. "It's important we don't throw the baby out with the bathwater here. There are many components that have a very important role to play in nutrition and in safety," he said.

Benefits of food processing include the use of preservatives that make food last longer and artificial sweeteners that help people reduce their sugar intake, said May. Other examples of processed foods that can be beneficial include baby food, infant formula milk and cereals and breads fortified with vitamins and minerals, said the panel.

The UK's Scientific Advisory Committee on Nutrition (SACN) published a report in July that concluded the studies linking UPF with poor health could simply be down to these foods being high in saturated fat, sugar and salt.

"SACN is absolutely concerned about the association between highly processed foods with a range of adverse health outcomes. However, we think it's unclear whether the associations are due to the nutritional characteristics of the food or whether there's any independent effect of the processing," said Ian Young, head of SACN. Further evidence will be reviewed as it emerges, he says.

But van Tulleken says that the evidence against UPF is robust. "There is an increasing amount of science describing the many ways in which UPF affects the human body," he says. "The destruction of the food structure by industrial processing means that UPF is, in general, soft. This means you eat it fast, which means you eat far more calories per minute and don't feel full until long after you've finished." ■

Technology

Heatproof computer could help probe Venus or the sun

A COMPUTER memory device that can withstand more than 500°C could be used in spacecraft sent to explore Venus or the sun.

Computers use a technology called non-volatile memory to store data even after their power supply has been switched off – without it, today's computers would consume too much power to be practical. However, these devices can't withstand temperatures above 300°C, which means in extreme environments like the surface of Venus, which reaches 475°C, they need to be protected with bulky, expensive insulators.

Now, Deep Jariwala at the University of Pennsylvania and his colleagues have tested a kind of computer memory made from the semiconductor scandium aluminium nitride. This is a ferroelectric material, which means it can store electric charges. The researchers sandwiched the semiconductor between platinum and nickel, which can both withstand hot conditions (arXiv, doi.org/kv4f).

The device could endure at least 6 hours in temperatures above 500°C and retain its memory. Based on theoretical calculations, it should last for longer and at higher temperatures, but the measurement devices couldn't function beyond this level of heat, says Jariwala.

It is unclear how much information the device can store, because the team didn't test this.

500°C

A new memory device can survive temperatures higher than this

But it can be made very thin, which suggests it has a fairly high information density, up to a few kilobytes, says Jariwala. It is also compatible with silicon carbide computing devices, which are the most commonly used high-temperature electronics, he says.

"Any spacecraft that you might send further along, to probe the sun or something like that, is going to experience elevated temperatures. If you want to get rid of the packaging and cooling to save weight and power, this would be quite appropriate," says Jariwala. ■

Alex Wilkins

Zoology

Elusive Australian bat sometimes snacks on other bats

Alice Klein

AN AUSTRALIAN bat thought to mainly eat insects also consumes other bats, according to an analysis of its droppings.

The greater broad-nosed bat (*Scoteanax rueppellii*) mostly lives along the coast and foothills of New South Wales. It is poorly understood because it is difficult to capture, says Brad Law at the New South Wales government's Department of Primary Industries. "They mostly fly above the height at which we can set our traps."

Over a 12-year period, Law and his colleagues managed to catch 12 of the bats in New South Wales using traps made from thin fishing line or fine mesh. The animals accidentally flew into the traps because they couldn't detect them with their echolocation calls.

The bats were kept for no more than a day before being released, and any faeces they left behind were analysed. They appeared to mainly eat beetles, but large amounts of hair matching that of other bats – such as the little forest bat (*Vespadelus vulturnus*) – were found in some droppings (*Australian Mammalogy*, doi.org/kv37).

Law had suspected that greater broad-nosed bats sometimes ate other bats after he and others occasionally found them in traps alongside the half-eaten remains of other bats, but the faecal analysis provides the most conclusive evidence yet, he says.

Greater broad-nosed bats are bigger than many other bat species, weighing roughly 25 to 30 grams, and have sharp teeth for crunching insect exoskeletons, meaning they would be equipped to attack smaller bats, says Law. "But there's still a lot we don't know, including whether they're able to catch other bats while they're out flying around, or if they get them in the daytime while they're roosting," he says. ▮

Physics

Antimatter definitely doesn't fall up, physicists confirm

Alex Wilkins

IF YOU drop a bit of antimatter, it will fall down to the ground just like regular matter, according to the first ever measurement of how these strange particles are affected by gravity. While this rules out the idea that antimatter could fall up, along with the existence of repulsive matter and antigravity machines, there is still enough uncertainty in the measurement for it to have slight differences from regular matter and for new physics to be at play.

Quantum mechanics says many particles should have an antimatter counterpart, identical in every way apart from an opposite electric charge. This flipped charge shouldn't change how gravity affects the particle. All particles with mass should move through space in the same way under gravity, according to Albert Einstein's theories. But it has been exceedingly tricky to test whether this is true because antimatter annihilates whenever it meets its opposite particle, making it difficult to produce and store enough of it.

Now, Jeffrey Hangst at Aarhus University in Denmark and his colleagues have measured how gravity affects antihydrogen, which consists of an anti-electron, or positron, and an antiproton. While normal matter on Earth accelerates while falling at a rate of around 9.81 metres per second squared, also known as *g*, the team found that antimatter fell at between 0.46*g* and 1.04*g* – in other words, definitely downwards (*Nature*, doi.org/kv38).

"When most people think about antimatter, they think of the science fiction thing of 'it'll fall up'"

"Most people, when they think of antimatter, they think of the science fiction thing of 'it'll fall up' – we can definitely rule that out," says Hangst. "What we can't rule out is there being some small difference between the accelerations [of matter and antimatter]."

Hangst and his team built a series of vertically stacked chambers to produce and store antihydrogen for their ALPHA-g experiment at the CERN particle physics laboratory near Geneva, Switzerland. The chambers are fed with positrons from a radioactive source and antiprotons from a particle accelerator, both of which are slowed down and kept at temperatures just above absolute zero. The two types of antimatter particles are then combined in a single chamber, producing about 20 neutral antihydrogen atoms every 4 minutes that are held in place by powerful magnetic fields.

The researchers released the magnetic fields at the top and bottom of the chamber over 20 seconds and counted the atoms that came out in both directions. Because some of the atoms will randomly have enough energy to come out of the top of the trap, Hangst and his team were looking for statistical imbalances of more particles coming out at the bottom, towards Earth.

"From a technological point of view, it's really outstanding," says Tara Shears at the University of Liverpool, UK. Particle accelerators typically make particles go very fast, and trapping them at speeds slow enough to measure gravity's effect is very difficult, she says.

While the team found that antihydrogen falls towards Earth with enough precision to rule out the idea that antimatter repels, rather than attracts, other experiments, such as the AEgIS and GBAR ones at CERN, will help us better understand if there are more subtle differences between matter and antimatter, says Shears. ▮



SAKKMESTERKE/ISTOCKPHOTO/GETTY IMAGES

An illustration of the trajectories of matter and antimatter

New Scientist Live

The hardest problem in physics
Hear Eugene Lim discuss quantum gravity on 8 October
newscientist.com/nslmag

Palaeontology

Trilobite stuffed itself with food

FOR the first time, a trilobite fossil has been found with preserved gut contents, and it hints the animal had a voracious, unfussy appetite.

"Most fossil trilobites are not dead whole animals, but rather shed carapaces from the moulting process, like modern crabs," says Per Ahlberg at Uppsala University in Sweden. But this 465-million-year-old trilobite (*Bohemolichas incola*), unearthed in the Czech Republic, was buried alive with a full gut. Ahlberg and his colleagues scanned it using X-rays and found that the arthropod ate a variety of living and dead marine organisms (*Nature*, doi.org/gssr57).

Judging by digestion, "it seems to have been eating very quickly, stuffing itself almost to bursting", says Ahlberg. He suspects the trilobite was over-eating to trigger moulting. **Corryn Wetzel**



SERGIO AMITI/GETTY IMAGES

Anthropology

Baskets made by prehistoric weavers

INTRICATE baskets and shoes found in a Spanish cave show that people in Europe thousands of years ago were skilled at weaving.

Excavations at Cueva de los Murciélagos, or the Cave of the Bats, have revealed several mummified corpses alongside objects including baskets, sandals and a wooden hammer.

Francisco Martínez Sevilla at the University of Alcalá in Spain and his colleagues have now analysed 76 of these artefacts. About 65 are made from a fibre called esparto grass. This includes baskets and sandals. The team carbon-dated 14 objects and found that they belonged to one of two time periods: 7950 to 7360 BC or 4370 to 3740 BC (*Science Advances*, doi.org/kv8j). The oldest sandal was about 6000 years old, which makes it the oldest shoe found in Europe, says Martínez Sevilla. **Chen Ly**

Genetics

We finally know what makes orange carrots orange

THE genes that make carrots orange have finally been identified, giving biologists a better understanding of what makes them so nutritious.

The first domesticated carrots were grown in central Asia in the 10th century, and they were originally purple or yellow. Orange carrots appeared in western Europe in the 1400s, probably as a result of crossing yellow and white carrots.

Since then, orange carrots have surged in popularity. Now, Massimo Iorizzo at North Carolina State University and his colleagues have uncovered the science behind the distinctive colour. They sequenced the genomes of 630 types of carrot, looking for gene variants associated with particular traits.

The researchers found three genes where orange carrots had variants that resulted in the gene being switched off. In purple, yellow or white carrots, at least one of the three genes was turned on.

These genes regulate levels of alpha-carotene and beta-carotene – chemicals that belong to a group of pigments called carotenoids. Alpha and beta-carotene are converted to vitamin A in the human body, which is important for the eyes and the immune system, for example.

When these genes are switched off, carrots produce more of these pigments, which generate their orange hue as well as making them a rich source of vitamin A, says Iorizzo. Other carrots have higher levels of other carotenoid pigments that aren't converted into vitamin A (*Nature Plants*, doi.org/kv5f).

Many orange carrots also had gene variants that delay flowering, keeping them tasty for longer. "Farmers have been unknowingly selecting these beneficial traits for centuries," says Iorizzo. **CL**

Really brief



Exoskeleton suit helps you run faster

An exoskeleton suit that boosts leg motion helps people sprint faster, according to a small study. Non-elite runners sprinted a 200-metre race 0.97 seconds faster while wearing the exosuit, which weighs 4.4 kilograms, than they did when they ran as normal (*Science Robotics*, doi.org/gssv6g).

Why nuts dance in fizzy drinks

When an object like a raisin or nut is dropped into a carbonated liquid, bubbles gather on its exterior and push it upwards. Once it reaches the surface, the object loses its top layer of bubbles. Then it sinks again and picks up new bubbles in a bobbing process that can continue for hours (arXiv, doi.org/kv8h).

Books help people trust you on Zoom

People come across as more trustworthy and competent on Zoom calls if they have plants or books behind them, according to a study in which 167 people ranked pictures of adults in front of different backgrounds. Smiling also evoked these positive impressions (*PLoS One*, doi.org/kv8n).

ASSISTIVE AND REHABILITATION ROBOTICS LAB AT CHUNG-ANG UNIVERSITY



How can artificial intelligence supercharge your business?

That was the theme of *New Scientist*'s first B2B event, which took place in central London last week.

Start-up founders, policymakers and scientists at the cutting edge of the AI revolution all took to the stage in front of a packed audience of senior business leaders at *New Scientist*'s AI Unleashed event. "Every business will become a tech-involved business. This isn't a prediction of the future, it's already a reality," said Paul Scully, UK minister for tech and the digital economy, in his opening address.

Some of the highlights of the day included Victoria Edwards, CEO of FIDO Tech, explaining how AI can be used to listen to water pipes to work out where they are leaking. Thirty per cent of the world's piped water is lost through leaks. AI can help us do better, she said.

David Wakeling told the story of how law firm Allen & Overy got in early on ChatGPT to build its own AI legal assistant, Harvey, that can help draft legal documents. It saves those who use it an average of 2 hours a week – across thousands of lawyers that soon adds up to a substantial saving, he said.

One session looked to the future, explaining what technology is coming down the line. Darshan Chandarana, emerging technologies leader at PwC, said that at the moment companies are using AI for productivity increases, but soon we're going to start seeing completely new business models made possible because of AI. "Your first few projects will probably fail," he said. So you've got to make sure you factor that in, he said.

Overall, the event was an effective primer on the opportunities and risks of AI for businesses. As *New Scientist* editor-in-chief Emily Wilson said, the AI we have today is "already enough to change your job and your industry". Now, we're getting a better sense of how. ■

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Timothy Revell is *New Scientist*'s deputy US editor and co-host of its weekly podcast

The columnist
Alex Wilkins ponders how much we should trust the new AIs p20

Aperture
Revel in the golden glow of our greatest space telescope p22

Letters
Heated views on climate politics and disinformation p24

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A new exhibition charts the evolution of family life p26

Culture columnist
Simon Ings delivers his verdict on sci-fi film *The Creator* p28

Comment

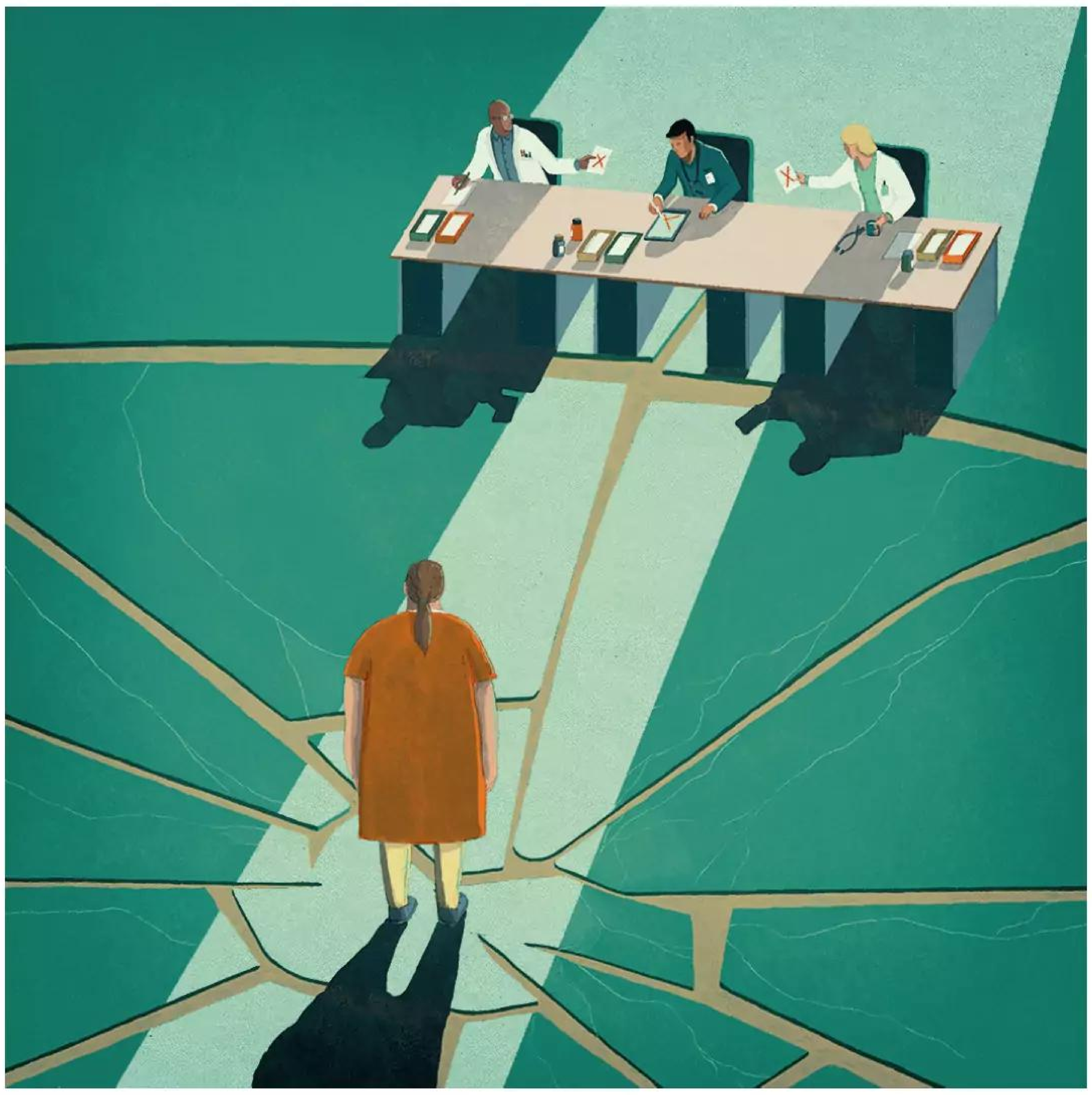
End the stigma of weight

Anti-obesity efforts are so intertwined with body-shaming attitudes that they actively harm health and well-being, says **Becca Muir**

WE ALL know how to lose weight, it is simple: eat less, move more.

This sounds logical enough on the surface. The problem is, within this "calories in, calories out" message there is an implied meaning: if you can't follow these instructions, you must be lazy or lacking self-discipline.

Of course, this doesn't reflect reality. There is plenty of evidence showing that losing weight isn't easy and that it is rarely sustained in the long term. Even newer weight-loss drugs such as Wegovy can lead to weight gain when you stop taking them. How heavy we are isn't solely under personal control, as our genetics and environment have a huge impact.


SIMONE ROTELLA

And yet weight stigma, which describes the negative attitudes, discrimination and harmful stereotypes directed towards people with larger bodies, is mainly predicated on this personal control narrative. That narrative, say researchers, has an insidious effect on the well-being and health of people labelled as "obese".

There is a view that this stigma motivates people to improve their health. But for those who experience it, the opposite can be the case. They have increased risks of depression and suicidality and report poorer self-esteem. It is also linked to higher levels of the inflammatory C-reactive protein, which is associated with stress and can raise the risk of cardiovascular disease and diabetes.

Sadly, weight stigma runs deep in many healthcare systems. As a researcher looking at how fertility treatment is rationed, I have been surprised by how embedded weight discrimination is in public health policies. For example, women categorised as "obese" are often excluded from IVF until they lose weight. But this doesn't consider individual health circumstances, and it isn't always well supported by scientific evidence.

Shaming people for their size can even lead to weight gain. Such stigma is linked to overeating, as it may activate a threat response: increased anxiety and stress because of feeling judged and devalued by others. People who feel less capable of controlling their intake may turn to comfort eating when they sense threat, says Erin Standen, who studies weight stigma at the University of Minnesota. That isn't all. She also explains that people with larger bodies often try to mitigate against this threat in a way that once again risks their health – they might stop exercising in public due to negative comments.

Another consequence of weight stigma is healthcare avoidance. A weight-centric approach by doctors can create mistrust between patient and physician and even lead to delays in cancer screenings. A survey found those who felt bad about their own weight believed doctors didn't respect them or listen carefully enough to their health concerns.

"Too often, patients feel blamed for their weight by healthcare providers," says Rebecca Puhl at the Rudd Center for Food Policy and Health at the University of Connecticut. To change this, rather than making it all about weight loss, doctors can emphasise other positive changes, such as mobility improvements, to help healthcare become more weight-inclusive, says Puhl. This will help people feel empowered, not stigmatised.

Multiple scientific and medical organisations have condemned weight stigma and committed to incorporating new knowledge on weight discrimination into their practices. This is a positive step, but such stigma is in all parts of society, and healthcare won't become weight-neutral until public attitudes also change.

Ending the view that "obesity" is a personal failure of willpower is difficult. But we need to recognise that focusing so much time, energy and money on the "war against obesity" in the way we have has inadvertently created a new public health problem. ▮



Becca Muir is a PhD candidate at Queen Mary University of London @beccalmuir

Artificially Intelligent

Mysterious models The world has happily accepted large language models, but even researchers working in AI don't fully understand the systems they work on, finds **Alex Wilkins**



Alex Wilkins is a *New Scientist* reporter covering artificial intelligence, physics and space. Artificially intelligent is a column that cuts through the hype and looks at what AI is really capable of and what it means for us. You can follow him @AlexWilkins22

Alex's week

What I'm reading
The Paris Review Interviews, Volume II, *insights from the most decorated writers of the 20th century. There are a million gems in each interview.*

What I'm watching
I've been catching up on 70s horror flicks. Jaws *hasn't aged a second, and* Picnic at Hanging Rock *was intriguing.*

What I'm working on
Like much of the New Scientist *team, I've been working on various bits and pieces for this year's New Scientist Live.*

This column appears monthly. Up next week: Chanda Prescod-Weinstein

SILICON Valley's feverish embrace of large language models (LLMs) shows no sign of letting up. Google is integrating its chatbot Bard into every one of its services, while OpenAI is imbuing its own offering, ChatGPT, with new senses, such as the ability to "see" and "speak", envisaging a new kind of personal assistant. But deep mysteries remain about how these tools function: what is really going on behind their shiny interfaces, which tasks are they truly good at and how might they fail? Should we really be betting the house on technology with so many unknowns?

There are still large debates about what, exactly, these complex programs are doing. In February, sci-fi author Ted Chiang wrote a viral piece suggesting LLMs like ChatGPT could be compared to compression algorithms, which allow images or music to be squeezed into a JPEG or MP3 to save space. Except here, Chiang said, the LLMs were effectively compressing the entire internet, like a "blurry JPEG of the web". The analogy received a mixed reception from researchers: some praised it for its insight, and others accused it of oversimplification.

It turns out there is a deep connection between LLMs and compression, as shown by a recent paper from a team at Google Deepmind, but you would have to be immersed in academia to know it. These tools, the researchers showed, do compression in the same way as JPEGs and MP3s, as Chiang suggested – they are shrinking the data into something more compact. But they also showed compression algorithms can work the other way, too, as LLMs, predicting the next word or number in a sequence. For instance, if you give the JPEG algorithm half of an image, it can predict what pixel would come next better than random noise.

This work was met with surprise even from AI researchers, for some because they hadn't come across the idea, and for others because they thought it was so obvious. This may seem like an obscure academic warren that I have fallen down, but it highlights an important problem.

Many researchers working in AI don't fully understand the systems they work on, for reasons of both fundamental mystery and for how relatively young the field is. If researchers at a top AI lab are still unearthing new insights, then should we be trusting these models with so much responsibility so quickly?

> **"If researchers are still unearthing new insights, then should we be trusting these models so quickly?"**

The nature of LLMs and how their actions are interpreted is only part of the mystery. While OpenAI will happily claim that GPT-4 "exhibits human-level performance on various professional and academic benchmarks", it is still unclear exactly how the system performs with tasks it hasn't seen before.

On their surface, as most AI scientists will tell you, LLMs are next-word prediction machines. By just trying to find the next most likely word in a sequence, they appear to display the power to reason like a human. But recent work from researchers at Princeton University suggests many cases of what appears to be reasoning are much less exciting and more like what these models were designed to do: next-word prediction.

For instance, when they asked GPT-4 to multiply a number by 1.8 and add 32, it got the answer right about half the time, but when those numbers are tweaked even slightly, it never gets the answer correct. That is because the first formula is the conversion of centigrade to Fahrenheit. GPT-4 can answer this correctly because it has seen that pattern many times, but when it comes to abstracting and applying this logic to similar problems that it has never seen, something even school kids are able to do, it fails.

For this reason, researchers warn that we should be cautious about using LLMs for problems they are unlikely to have seen before. But the millions of people that use tools like ChatGPT every day aren't aware of this imbalance in its problem-solving abilities, and why should they be? There are no warnings about this on OpenAI's website, which just states that "ChatGPT may produce inaccurate information about people, places, or facts".

This also hints that OpenAI's suggestion of "human-level performance" on benchmarks might be less impressive than it first seems. If these benchmarks are made mainly of high-probability events, then the LLMs' general problem-solving abilities might be worse than they first appear. The Princeton authors suggest we might need to rethink how we assess LLMs and design tests that take into account how these models actually work.

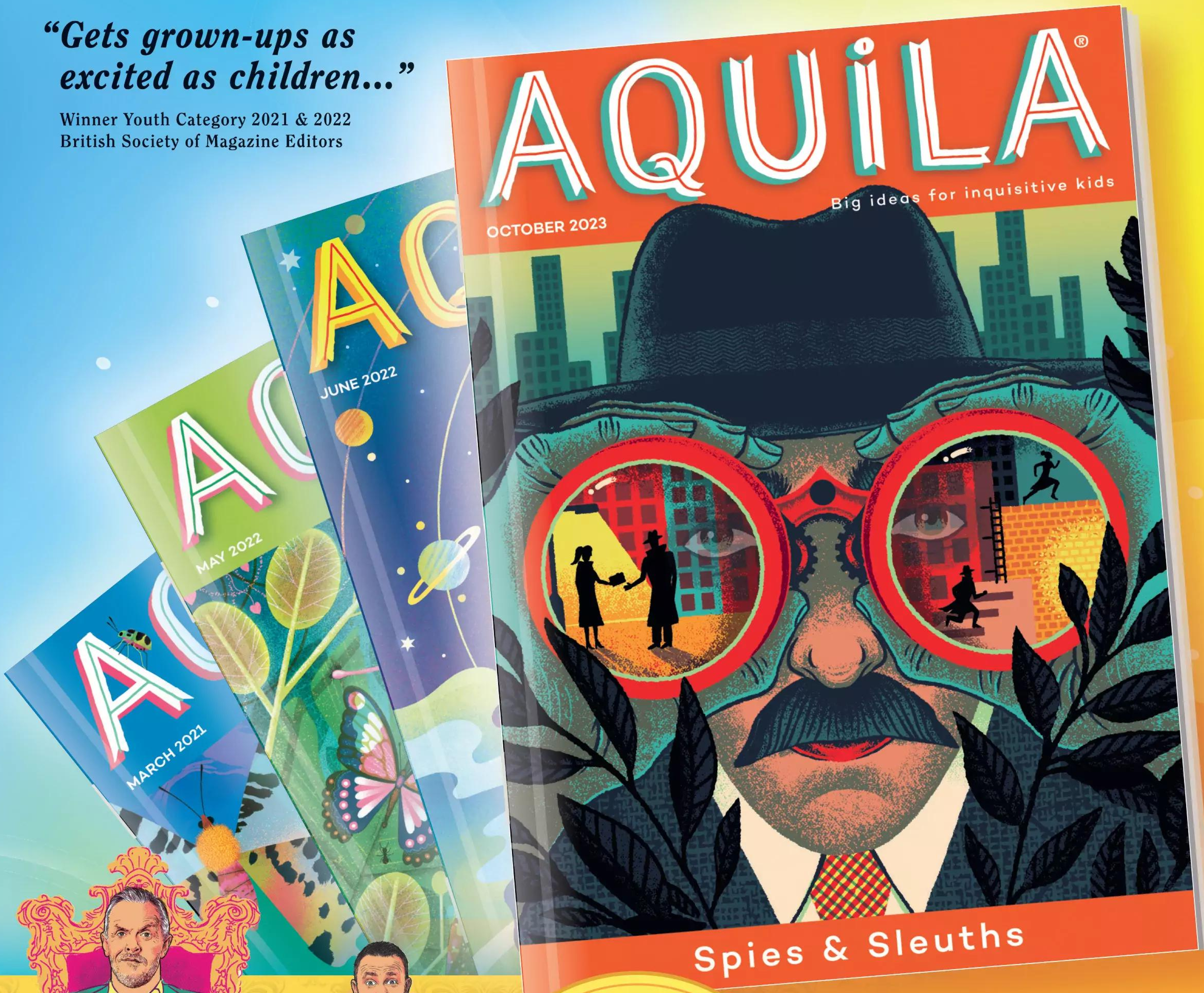
Of course, these tools are still useful – many tedious tasks are high-probability, frequently occurring problems. But if we do integrate LLMs into every aspect of our lives, then it would serve us, and the tools' creators, well to spend more time thinking about how they work and might fail. ▮

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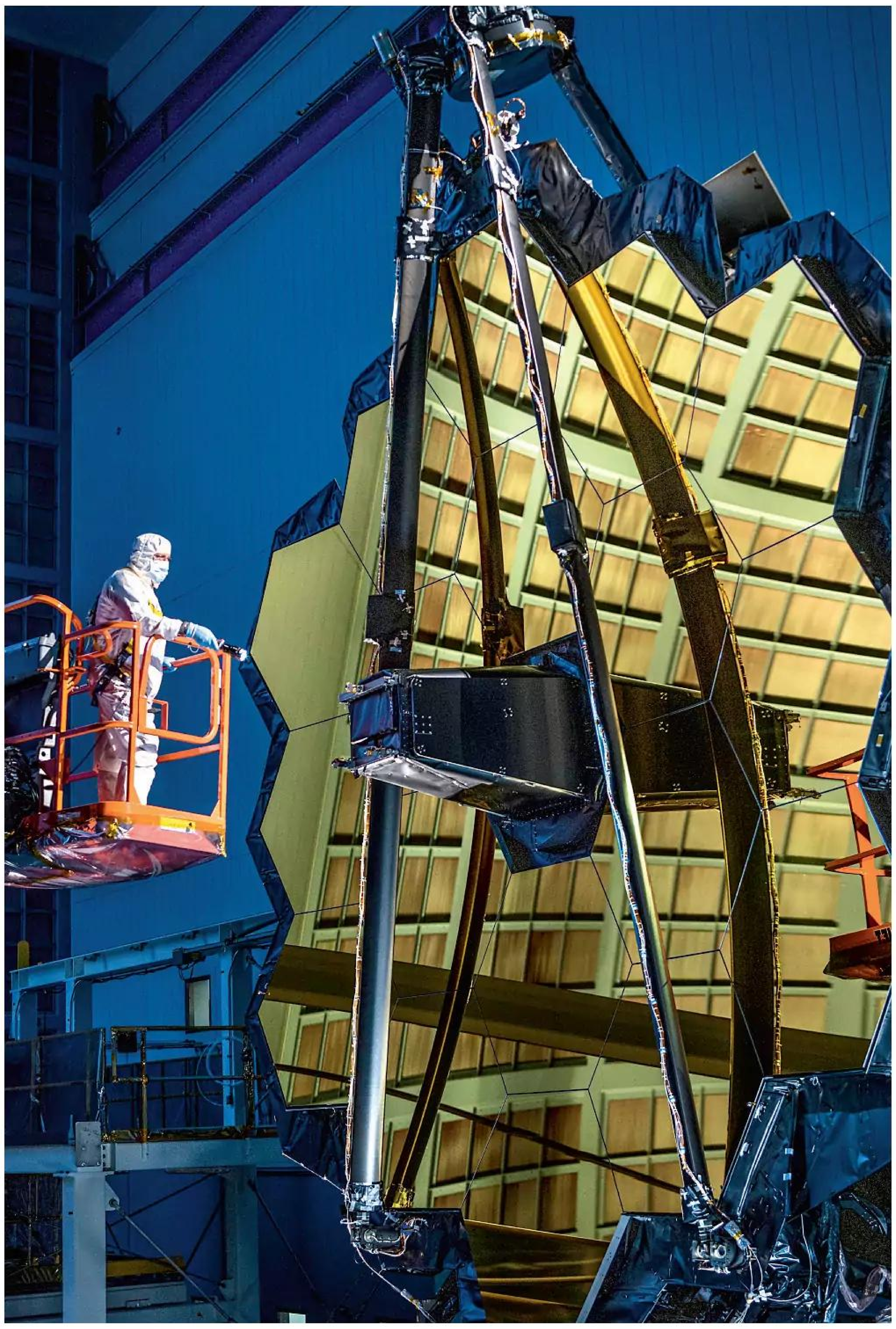
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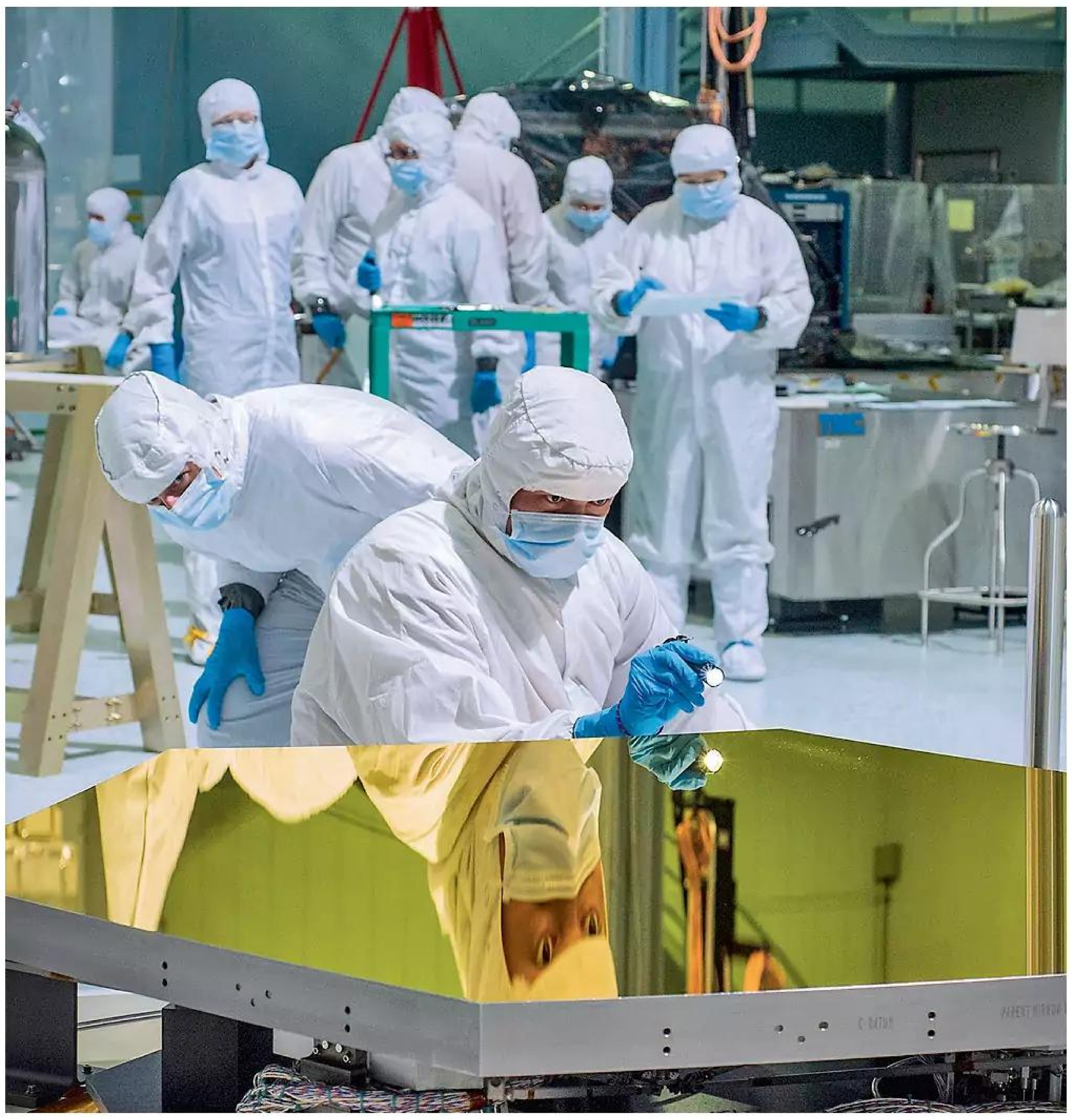
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A golden age

Photographer Chris Gunn for NASA

THESE photos offer a glimpse into an extraordinary project three decades in the making: the James Webb Space Telescope, or JWST.

Launched in 2021 on Christmas Day, JWST took its first image in July 2022, laying bare a field of never-before-seen galaxies in unprecedented clarity. It has since uncovered new exoplanets and the area around a supermassive black hole, while upending what we thought we knew about the early universe and astronomical objects such as nebulae.

Its conception, development and launch are documented in a new book, *Inside the Star Factory*, by photographer Chris Gunn and writer Christopher Wanjek. Taken from the book, the far left image from 2017 shows JWST's Optical Telescope Element (OTE, known as its "eye"). Its 18 gold-plated mirrors together form a 6.5-metre-wide reflector for infrared light.

Part of what makes JWST more sensitive than its predecessor, the Hubble Space Telescope, is the fact that it sees in infrared, so it can scour interstellar distances beyond the visible light spectrum. Another crucial element is the huge reflector – six times the size of Hubble's – that allows the visualisation of far-off objects and phenomena.

The OTE and reflector are undergoing a nighttime, lights-off inspection in the image at top right, while the image below captures the first moments the mirrors were unveiled, as an engineer assesses the surface of one of them for any artefacts. "I remember standing in the glow of the gold and realizing that I had never stood next to something so precious," writes Gunn in the book, which is out on 17 October.

Gege Li

Editor's pick

The new climate message: procrastination is OK

30 September, p 13

From Rod Newbery, Cambridge, UK

UK prime minister Rishi Sunak says it is OK to carry on installing gas boilers until 2035 because the lifetime of these devices means most of them will be replaced by 2050, when the country has pledged to reach net zero. Similarly, we can keep buying new fossil fuel-powered cars until 2035, instead of the original 2030 target.

It seems the logic is that we don't need to do anything to meet the 2050 target until 2035. Other measures – like requiring landlords to improve home insulation, taxing long-haul flights, encouraging car sharing and promoting less meat in diets – also won't be introduced, which reinforces this view. I fear the message many will take from this is that there is no need to change their lifestyle until 2035.

Perhaps the cosmic voids aren't so empty after all

23 September, p 16

From Stan Collins, Kendal, Cumbria, UK

If the lambda-CDM model of the universe doesn't seem to be working, perhaps the reason is that one of its assumptions is wrong: that the distribution of galaxies is a cosmic web. It could equally be a cosmic foam, which would look much the same. The difference would be that the voids contain an active agent exerting pressure on the visible matter.

How to stem the rising tide of disinformation

16 September, p 36

From Geoff Harding, Sydney, Australia

The spread of disinformation by social media has the potential to destroy rational thought and judgement. Every child should be taught that consumption and acceptance of demonstrably incorrect information is tantamount to contamination of the most important organ in the body, the brain, with potential negative consequences.

How to filter it out? All information sourced from third parties should contain a reference to the original source, plus any refutation, if it exists. Any that isn't adequately referenced or originates from a source that doesn't appear authoritative should be regarded with suspicion, if not totally rejected.

From Robert Peck, York, UK

The fundamental truth is that open, uncensored debate is still the best way to expose and defeat falsehoods.

Choose your future fate: unsurvivable heat or flood

16 September, p 8

From Jonathan Wallace, Newcastle upon Tyne, UK

In your report on the potential for mass deaths in heatwaves provoked by climate change, two experts quoted seem to downplay the risk because "even if it's hot outside, it doesn't mean that it's hot inside" and "all heat-related impacts on human health... are preventable". These are true to an extent, but fail to account for the many (mostly poor) people who are obliged to work outside and who have limited access to shelter, let alone air conditioning.

From Guy Cox, Sydney, Australia

Of course we need to be concerned about hotter conditions, but we should be more worried about another facet of climate change. It seems to be generally accepted that 2 metres of sea level rise is unavoidable, yet we don't seem to be fully considering what that will mean, especially for low-lying nations. And will it really just be 2 metres? In the last interglacial period, sea levels were 6 to 9 metres higher than today. I can't see civilisation surviving that.

If you should go down to the woods today

23 September, p 20

From Hillary Shaw, Newport, Shropshire, UK

Biophobia may stem from many sources. In the 1970s, we became dependent on prepacked food, supermarkets, microwaves and takeaways. In recent years, gardens have become manicured, with conservatories, ornaments, decking and non-native plants – in other words, with little that is truly natural. Horror films often feature a dark, sinister forest or other isolated wild place, giving the message that, apart from managed parks, such areas are where nasty things may happen. The message? Avoid natural wild things everywhere.

In soap operas, time really is relatively odd

16 September, p 22

From Maggie Cobbett, Ripon, North Yorkshire, UK

Having worked on *Emmerdale* and other soap operas, I know Chanda Prescod-Weinstein has a point about timescales in such shows making no sense, even if she was exaggerating a bit. I can recall at least one case of a prepubescent cast member vanishing only to be replaced soon after by an actor several years older. Viewers can hardly miss a character with winter pallor entering a pub, then appearing at the bar seconds later with a tan. Schedules rarely allow for scenes to be shot in direct order.

We can harvest lots of biomass to good effect

23 September, p 10

From Eric Kvaalen, Les Essarts-le-Roi, France

You report research that says it is bad for the planet if we use more than 10 per cent of all biomass. But we can actually solve problems by harvesting biomass. This doesn't mean deforestation, but using it in a sustainable way to sequester carbon. This would cut carbon in the atmosphere, reverse global warming and protect ocean pH.

On the mystery of the contents of the cell

Letters, 26 August

From Dan Levitt, Cambridge, Massachusetts, US

Thanks to Guy Cox for noting that, 100 years ago, chloroplasts were known to be structures in cells. In my article, I was referring to the state of knowledge in the 1920s and 30s about human cells. Outside the nucleus, the only structures known then were mitochondria, whose function was unknown, and putative Golgi bodies, believed to be artefacts of the cell-staining process. ▮

Want to get in touch?

Send letters to letters@newscientist.com; see terms at newscientist.com/letters

Letters sent to New Scientist, 9 Derry Street, London, W8 5HY will be delayed

For the record

▮ In our report on restoring US prairies (16 September, p 41), we should have quoted Shannon Eddy, director of the Large-scale Solar Association, on land-use changes on the opening page. In addition, the caption with the Daphne Prairie Preserve image should have referred to a planned solar facility near prairie land outside Mount Vernon, Texas. Finally, it is the federal government that is investing heavily in the US energy transition.

▮ The solution to Headscratcher #240 (30 September, p 47) went a bit awry. The correct one is at newscientist.com/puzzles



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Family matters

Scientific progress has made all sorts of families possible. But as a new exhibition shows, it hasn't been a pain-free shift, says **Alison George**

Exhibition

Real Families: Stories of change
Fitzwilliam Museum Cambridge, UK
6 October to 7 January 2024



ALIZA NISENBAUM. PHOTO COURTESY THE ARTIST AND ANTON KERN GALLERY, NEW YORK

This painting by Aliza Nisenbaum captures a family at rest on a Sunday

IN YOUR mind, conjure up a picture of a family. What do you see? A holiday photo with mum, dad and children grinning in the sunshine, perhaps, or a more formal image of relatives gathered at a wedding?

But do such mental images reflect the reality of many families today? This question is at the heart of a groundbreaking exhibition, Real Families: Stories of change, at the Fitzwilliam Museum in Cambridge, UK. Its more than 120 works of art, including paintings, photographs and sculptures by artists such as Alice Neel, Paula Rego, Lucian Freud, Tracey Emin and Chantal Joffe, explore the intricacies of modern family relationships.

The exhibition has its roots in the pioneering work of its curator, Susan Golombok, based at the Centre for Family Research at the University of Cambridge, who studies the new family set-ups made possible through scientific advances.

Since Louise Brown, the first test-tube baby, was born in 1978 following IVF, there has been a revolution in the ways families are created and structured. But these new family types prompted new concerns, with press reports about "Frankenstein" babies and fears that children would be harmed by being conceived from donor eggs or sperm, or by having gay parents.

"If it's something new, then there's a tendency to think that it's going be a problem," says Golombok, who became involved in family research in response to the forced removal of children from their lesbian mothers in the UK in the 1970s. At that time, says Golombok, there was no empirical research and custody cases were decided on assumptions and prejudices.

Her research showed that it is the quality of the relationships between a child and their caregivers that matters, not the family structure. She has since shown that this is also true for children who result from different methods of conception, whether they involve surrogacy or donated eggs, sperm or embryos – and even if there is no genetic link to the parents. "The absence of a genetic relationship to their parents generally doesn't seem to interfere with positive child-parent relationships," she says.

In fact, it is secrecy about a child's origins that can cause difficulties.

The idea to create an exhibition based on these findings, as well as wider research by the Centre for Family Research, originated in 2015, when Golombok saw the sculpture installation *Untitled (Possil, At Last)* by artist Cathy Wilkes, which depicts a dejected-looking man – possibly a father – with his back to two children. "It was really emotional and it struck me that it summed up a lot of our research about the ways families influence children," she says. This installation now forms part of the Real Families exhibition.

> "What matters is the relationships between child and caregivers, not family structure or method of conception"

The show starts conventionally, with a 1789 painting representing the traditional notion of family and lineage by Joshua Reynolds of the well-to-do Braddyll family, with mother, father and son against the backdrop of the family estate. But the boy's three sisters are missing: they won't inherit the family name or property, so have no place in this kind of status-setting portrait.

Most of the other artworks, however, are from recent decades, and highlight artists who portray new forms of family, as well as family dynamics and transitions. There are the colourful yet eerie *Halfboy* paintings by Stuart Pearson Wright, who was conceived by anonymous sperm donation. He felt like an anomaly in his family, and depicts himself standing awkwardly with his stepfather or by his half-sister. "A lot of his art is about how unhappy he was not knowing his biological father, feeling out of place in his family," says Golombok.

Most heartbreaking are the drawings Mary Husted made of her newborn son in the 10 days before she was forced by her family to give him up for adoption when she was 17, in the 1960s, and the collage she made in her 40s, which helped reunite them.

Equally poignant is the portrait by Li Tianbing (an only child as a result of China's one-child policy) showing him as a child with an imaginary brother. And there is Lucian Freud's tender painting of his mother in old age, resting.

Real Families delightfully challenges the stereotype of the nuclear family comprising husband, wife and their kids – now in the minority in the UK and US. As it shows, what matters for children is love and truth about their origins, and the exhibition is a colourful, thought-provoking and poignant celebration of this. ■

Nowhere to hide

A scary future is certain if we fail to safeguard the freedom of being anonymous in public, says **Wendy M. Grossman**

Book
Your Face Belongs to Us
Kashmir Hill
Simon & Schuster

IN 2011, two things happened within a few weeks. Eric Schmidt, then executive chair of Google, said the company had decided not to build a facial recognition database because doing so was "crossing the creepy line". Then Facebook released just such a feature, automatically tagging people in uploaded photographs, grouping them and asking users to identify anyone it couldn't. It eventually discontinued the system in 2021.

The creepiness has spread. Police in the UK used live facial recognition to scan for criminals at the coronation of King Charles. In New York, Madison Square Garden Entertainment has been caught using the tech to bar from its venues lawyers working for firms involved in litigation against it. The world's airports are starting to embed this tech in new infrastructure. In China, facial recognition has been built into toilet paper dispensers to stop theft. In the US, false matches have led to false arrests (and lawsuits).

These are all the kinds of things Kashmir Hill, a reporter for *The New York Times*, imagined when she first learned of Clearview AI via a tip-off. The tech firm had amassed a database of billions of faces scraped off the web, and its business model rested on selling access to that information to law enforcement. Having long specialised in privacy issues, Hill understood the size of the threat that the database posed.

Almost immediately, she found the firm was so secretive that every contact stopped answering her emails after her first questions. But Hill persisted, following leads and developing sources. In a January 2020 article, she alerted the world to "the secretive company that might end privacy as we know it".

For the first half of her highly readable new book, *Your Face Belongs to Us: The secretive startup dismantling your privacy*, Hill's chapters alternate between the origins of Clearview and the general history of facial recognition. These twin threads eventually join into a single narrative about the present and future of this technology.

A police facial recognition unit in Cardiff, Wales, near a Harry Styles concert in June



MATTHEW HORWOOD/GETTY IMAGES

Key among her characters is Clearview CEO Hoan Ton-That, who emigrated to San Francisco from Australia at 19 and spent a decade experimenting with a variety of uninspired apps (including, inevitably, one to let you rate other people's appearance) before moving to New York and hitting on the idea of face matching. As Hill makes clear, the technological pieces were already within reach. Crossing the creepy line just took an ambitious entrepreneur with no inconvenient ethical concerns, steeped in the Silicon Valley ethos of "ask forgiveness, not permission".

Finding investors was expedited by the 6 January 2021 insurrection, when supporters of Donald Trump stormed the US Capitol building in Washington DC. Clearview helped investigators seeking to identify the participants – apparently unhindered by mounting fines in the European Union or by its business-limiting settlement with the state of Illinois under the Biometric Information Privacy Act.

As Hill's later chapters show, if we do nothing, the de-anonymised future hurtling towards us will allow anyone with a modicum of technical ability to cobble together a face search engine to fit in their pocket. And not just face: besides the potential for DNA samples and other biometrics, enough video is posted daily to enable a database of highly identifiable gaits.

Towards the end of the book, we find Ton-That experimenting with a pair of glasses that can isolate any face in your field of vision and show matches from a Clearview search. In the world he demonstrates with those glasses, one that Hill fears, no one will ever be anonymous in public again – a liberty we may only fully understand when it is gone. ■

Wendy M. Grossman is a technology writer based in London

New Scientist *recommends*



Jacob Aron
News editor
London, UK

My wife and I have been glued to the second season of **Star Trek: Strange New Worlds**. As we watched, the stakes got higher – not in a narrative sense, but because I was coming



MICHAEL GIBSON/PARAMOUNT+/CBS

to the conclusion that it is the best season of *Star Trek* ever made and was waiting for the show to flub it. Luckily, it didn't, and I would recommend the series to anyone with even a passing interest in the franchise.

This season has it all: legal drama, Vulcan family farce and even a musical episode. It also has a great cast with real heft, led by Anson Mount (pictured) as Christopher Pike. He is fast becoming my favourite captain (well, second: sorry Pike, no one beats Picard).

I am also reading **The Defector**, the sequel to astronaut Chris Hadfield's **The Apollo Murders**. That book drew on his experience to present lunar warfare in an alt-history cold war. The sequel flies lower with Tom Clancy-style fighter jets and a sprinkling of reality from Hadfield's time as a test pilot. It is a thriller in every sense.

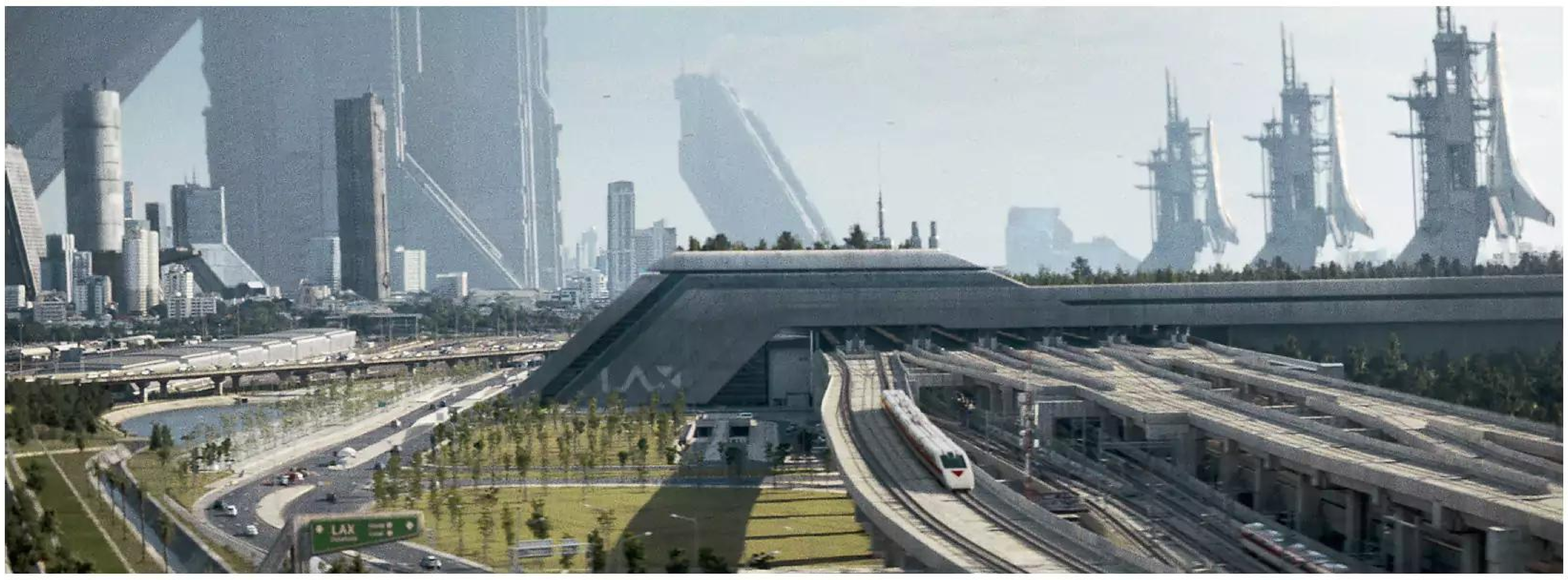
The film column

Playing sci-fi cinema bingo

Set during a futuristic war between humans and artificial intelligence, *The Creator* is nothing if not spectacular. Shame it is cobbled together from the tropes of other science fiction movies, says **Simon Ings**



Simon Ings is a novelist and science writer. Follow him on Instagram @simon_ings



DISNEY

Film
The Creator
Directed by Gareth Edwards
In cinemas

Simon also recommends...

Books
The Child Garden
Geoff Ryman
Gollancz
In this London of the future, biology is politics. Learning is viral. Sedition is treatable. Bodies photosynthesise and rice paddies feed the "child gardens". Ryman mashes together cultures to create a future as strange as it is true.

Mockingbird
Walter Tevis
Gateway
Humans are dying out, not because the robots turned against them, but because one has grown too tired to serve. A sly take on machine logic and its consequences.

A MAN loses his wife in a war with robots. The machines didn't kill her, human military ineptitude did. She was pregnant with his child. The man (John David Washington, whose heart-on-sleeve performance can't quite pull *The Creator* out of the fire) has nothing to live for, until it turns out his wife (Gemma Chan) is alive after all, and working with the robots. She has built them a weapon – a robot child (an irresistible performance from 7-year-old Madeleine Yuna Voyles) who can control machines at a distance. The man steals the child from its lab and they go in search of his wife, who is in hiding. They are a family in wartime, trying to reconnect, and their reconnection will change everything.

The Creator's great strength is its futuristic South-East Asian setting. (You know a film has problems when a reviewer launches straight in with the set design.) Police drones like mosquitoes rumble overhead. Mantis-headed robots in red robes ring temple bells to warn of US air attack.

This is *Apocalypse Now* Lite: the US aggressors have been traumatised by the nuking of Los Angeles, an atrocity they blame on their own artificial intelligence. They have hurled their robots into the garbage compactor (literally – a chilling, upscaled retread of that *Star Wars* scene). But South-East Asia has fallen in love with AI technology. The way a unified, *Blade Runner*-esque "New Asia" sees it, LA was an accident a long way away, people replace people all the time and a robot is a person.

Hence: war. Hence: villages annihilated under blue laser light and missiles launched from space against temple complexes in mountain fastnesses. If nothing else, it is spectacular.

The Creator is not so much a standalone sci-fi blockbuster as a game of science fiction cinema bingo. Huge battle tanks, as large

> **"Mantis-headed robots in red robes ring temple bells to warn of US air attack; this is *Apocalypse Now* Lite"**

as the villages they crush? Think *Avatar*. A very low-orbit space station, visible in the daytime? Think *Oblivion*. Child with special powers? Think *Stranger Things*.

This is a science fiction movie assembled from the tropes of other science fiction movies. If it isn't as bankrupt as Ridley Scott's *Alien* prequels *Prometheus* and *Alien: Covenant*, it is because we haven't seen South-East Asia

The Creator's great strength is its futuristic South-East Asian setting

cyborgised before (though readers of sci-fi have been inhabiting such futures for over 30 years) and also because director Gareth Edwards once again proves that he can pull warm human performances from his actors. This isn't nothing. Nor, alas, is it enough.

As a graduate, Edwards won a film contest in London and got the chance to make a low-budget feature, *Monsters* (2010). On the back of it, he got a shot at a *Star Wars* spin-off in 2016, which hijacked the entire franchise (everyone loved his *Rogue One*).

The Creator should have been his *Star Wars*. Instead, something has gone wrong in the editing. Vital lines are delivered in scenes so truncated it is as though the actors are explaining the film directly to the audience. Every few minutes, tears run down Washington's face, Voyles's chin trembles, and we have no idea what brought them to their latest crescendo – and, ooh look, that goofy running bomb! That reminds me of *Sky Captain and the World of Tomorrow*...

The Creator is a fine spectacle. What we needed, though, was a film with something to say.



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YOU AND YOUR MICROBIOME

The microbes in our gut, and their impact on body and mind, have become a hot topic. But how much of the science holds up? How can we change them for the better? And should their role in our lives change our view of who we really are?





SAM FALCONER

YOU may, quite reasonably, think you are an individual of the species *Homo sapiens*. Once you have finished reading what follows, you will hopefully have been convinced that there is far more to us than that. Trillions of other organisms live on (and, more notably, in) your body. As you will see in the reports that follow, their impact on you is such that you will probably never think about yourself in the same way again. Your microbes change who you are and what it means to be you. With knowledge of this facet of ourselves growing rapidly, exploring it has never been more relevant.

Until recently, scientists believed that there were three discrete parts of our nature that reflected solid aspects of an individual self: the immune system, the genome and the brain. "None of these pillars of the traditional definitions of the self – immunity, genome integrity, the central nervous system – are free of microbial impact," says Thomas Bosch at Kiel University in Germany.

The microbes that colonise us, collectively known as the microbiome, challenge the concept of a discrete self. These include bacteria, viruses and fungi, although the bacteria are the best-studied. Together, these microbes orchestrate the immune system, influence how the brain works and grows, and affect our personality and feelings. Over a third of the genes in the human genome have a bacterial origin, and the action of trillions of microbial genes in the gut has direct impacts on our nutrition and metabolism. Recognising this leads to the startling conclusion that a discrete human body isn't an individual, it is a "metaorganism". Bosch, who runs a metaorganism research centre, is one of a growing number of scientists who say the key elements that we believe make us individuals are themselves produced by interactions with microorganisms. If this is the case, we need to rethink what it means to be human.

"Certainly, the line that demarcates where we end and the external world begins is up for debate," says Geraint Rogers at the South Australian Health and Medical Research Institute in Adelaide.

This blurring of boundaries makes sense, given that we evolved on a microbial planet and that microbes were here long before us. "Fundamentally, we have always been part microbial," says Alan Walker at the University of Aberdeen, UK. This view has important implications for our position in nature, but also means we will need to change the way we treat ourselves when we are ill (see "The gut microbiome and chronic disease", page 36).

"We need to adapt to a holistic way of thinking that accounts for the full complexity of the interconnection between our gut, our mind and the trillions of microbes that live in our gastrointestinal system," says Harriët Schellekens at University College Cork in Ireland.

At the moment, however, we don't always know how to intervene and make adjustments: the system is just too complicated, with many unknowns. The best microbial-based treatment we have comes from using faecal transplants to treat recurrent infections of the bacterium *Clostridioides difficile* (see "Can pills and supplements boost your microbiome?", page 33).

Other than that, reliable, clinical evidence for a microbiome-based approach in medicine is only slowly accumulating. In one promising example, a trial in the UK looked at premature babies at risk of developing a dangerous, often fatal bowel condition called necrotising enterocolitis. The rate of the condition fell by more than half in babies given a daily dose of live, protective bacteria.

Gut-brain connection

Still, while the promise is huge, treatments that exploit the microbial community inside us have yet to catch up. Take the link between the microbiome and mental health. Our gut microbes produce many of the same neurotransmitters that are made in the brain, and use them to communicate with it. We all experience the intimate communication between the brain and the gut when we feel nervous, or butterflies in our stomach, but the connection goes deeper. Several studies have shown a correlation between a lack of certain gut bacteria and depression, as well as with anxiety – but we don't know if that link is causal. In rodent trials, faecal transplants from people with depression to rats seem to induce depressive behaviour in the rats. And in preliminary trials, when people with depression were treated with faecal transplants, their symptoms have improved.

Most transplant successes have been in conjunction with regular medical treatment and the improvement in symptoms isn't permanent. The long-term consequences of faecal transplants are also unclear. It all ›



means that reliable treatments are still a way off. "For me, this area is a bit 'watch this space' – I wouldn't be treating depression by treating the microbiome," says Walker, who adds that this is certainly not something people should self-administer.

For his part, Rogers says that the microbiome clearly has the capacity to explain differences in clinical outcomes between individuals. We take into account genetic predispositions and existing conditions when we treat someone, he says, and it is increasingly clear that we should add the microbiome to that list.

All this has profound implications for what it means to be human. For hundreds of years, people have considered themselves apart from nature, which has led to an unfolding crisis of overexploitation of the environment. "Humans were always thinking they were different, they were better than nature, they looked at nature as something foreign," says Bosch. "We have to go back to thinking that we are all part of an integrated, living cosmos. We are not better or separate – if we look in our own body, we are full of nature."

Rowan Hooper

> **"Humans aren't different or separate – if we look into our bodies, we are full of nature"**

WHERE DOES YOUR GUT MICROBIOME REALLY COME FROM?

Imagine a remote island, recently formed by volcanic activity, in the middle of the ocean. At first, it is lifeless, but a growing variety of plants take hold, providing food for pioneering animal species, until eventually there is a diverse and flourishing ecosystem.

This is a useful way to think about how our gut ecosystems develop. "Your microbiome goes on a journey," says Alan Walker at the University of Aberdeen, UK. "When you're born, some bugs get in and then, when you start eating solid foods, other bugs replace them. There's a dynamic process where your microbiome changes until you get to mid-to-late childhood. Then, through adult life, you've got a reasonably stable microbial community."

The first individuals that colonise an island can have long-lasting influences on its ecosystem, an idea known as the founder effect. Until recently, the thinking went that if the founder bacteria in a baby's gut were unusual – because the baby was born by Caesarean section, for instance – this might disrupt their bacterial ecosystems. This idea has led some parents to take radical steps to get their children's microbiomes back on the right track. But the science behind these ideas is far from settled.

One of the first to document the differences between the gut bacteria of babies born by C-sections and those born vaginally was Maria Gloria Domínguez-Bello at Rutgers University in New Jersey. Her research team found that when babies born by C-section were a day old, their faeces had fewer bacteria normally found in the vagina and more of the bacteria that usually colonise the skin. "Babies are like sponges and they get whatever they're exposed to," she says.

Bacteria for babies

Previous studies have found that C-section babies go on to have slightly higher rates of certain health conditions, including obesity, allergies and asthma. As disturbed gut bacteria have been claimed to contribute to these conditions, the concern is that C-sections could be causing lasting harm to children's health.

To counter this, Domínguez-Bello's group helped pioneer the practice of "vaginal seeding", where a baby's face and mouth are wiped with a piece of gauze that was previously placed in their mother's vagina. Crucially, this is only done after tests to check there are no harmful microrganisms in the mother's vagina.

Some researchers are even giving C-section babies small oral doses of their mothers' faecal bacteria (again, they are screened for harmful microbes). But the trials done so far have had small numbers of participants, so this isn't yet considered of proven medical benefit.

Besides, even the basic premises behind the idea are up for debate. The health conditions of interest, such as obesity and allergies, haven't been shown to be caused by altered gut

New Scientist Live

Brain-shaping environments

Hear neurologist Suzanne O'Sullivan discuss how brain, body and society shape disability **newscientist.com/nslmag**

bacteria – only to correlate with them. It could be something else, such as diet or lifestyle, causing both the medical condition and the microbiome differences. In fact, a recent review co-authored by Walker concluded that, so far, no reliable microbial signatures of obesity have been found (see "Does the gut microbiome influence body weight?", page 39).

Most importantly, it is questionable if a child's mode of birth has a lasting effect on their microbiome. A 2018 study found that, in vaginally born babies, bacteria from the mother's vagina are found in the baby's gut for only a few days, while the mother's gut bacteria continued colonising the baby's gut for months after the birth.

A much bigger influence comes from whether or not babies are breastfed, as breast milk contains some sugar-like compounds – absent in most types of baby formula – that promote the growth of *Bifidobacterium* bacteria. This is thought to be beneficial for several reasons, including blocking colonisation of the gut by harmful bacteria. Then, as babies are weaned onto solid foods in their first year, their microbiome starts becoming more like that of an adult.

As children grow, the biggest influence on their gut bacteria is the people they live with (see "How are our microbiomes shaped by our social relationships?" page 38). "When people go to the toilet, there will be bugs floating around the house that are derived from stools," says Walker. One study of a family with six children found that, by a few years of age, the children shared about the same number of gut bacteria with their father as with their mother.

Much is still unclear about how our gut ecosystems bloom into their full complexity and individually unique make-up – even differing between identical twins. "A lot of it seems to be quite random and what you're exposed to," says Walker. "Certainly, in adults, there's no way to tell if someone was breastfed or was born by C-section. The big question is how much that window where it was different really matters. There's lots to be learned."

Clare Wilson



CAN PILLS AND SUPPLEMENTS BOOST YOUR MICROBIOME?

If you have a condition like irritable bowel syndrome (IBS), a finnicky gut or just want to keep your microbiome in top condition, you might be tempted by products and treatments that offer a microbial tune-up. But what really works? Here are the main tools to engineer a better gut.

Probiotics

Probiotics are microbes that may help to restore healthy gut microbiota. If they also improve your mood, they are called psychobiotics. You can typically get them from eating naturally fermented foods like yogurt that contain beneficial bacteria, such as *Lactobacillus* or *Bifidobacterium*.

But as an adult, these microbes are unlikely to colonise your intestines. To the extent that they are helpful, their benefit comes while they are passing through. Such probiotics stimulate immune cells in the gut to reduce inflammation, increase mucus production and deter pathogens by producing lactic acid. But as mere visitors, they need daily top-ups.

Probiotic supplements have been used (with mixed success) for more than a century to help with the gut conditions of Crohn's disease, colitis and IBS. They have also been shown to help with weight loss in people who are overweight and are increasingly being used for other conditions, including bacterial vaginosis and urinary tract infections. What's more, they reduce the risk of antibiotic-associated diarrhoea.

As the gut microbiome can affect our mental health, it is perhaps unsurprising that psychobiotics are also being used to target our minds. Some studies suggest they may be able to help boost resilience to stress, reduce anxiety and improve mood and cognition in older people.

But there are caveats. Regulations governing the safety ›



ELEONORA GRIGORJEVA/GETTY IMAGES

of these products vary widely from country to country. In the US, the Food and Drug Administration applies a soft touch to probiotic nutritional supplements, as long as manufacturers don't claim to treat or cure specific conditions, so look for solid science behind any assertions and be wary if they sound outrageous. The European Food Safety Authority, however, isn't convinced of probiotic efficacy and hasn't approved any health claims to date.

Clinical trials are proceeding apace, but around a third of them are industry funded, so should be handled with care. Some of the best-studied probiotics include *Bifidobacterium longum*, *Lactobacillus rhamnosus*, and *Akkermansia muciniphila*. Clinical studies show that these appear to improve gut health by reducing bad bacteria and boosting beneficial ones. But it is still early days, and unless you have a specific condition, there are other ways you can keep your gut healthy (see "How to care for your microbiome (and keep it healthy as you age)", right).

Prebiotics

A prebiotic can be a dietary fibre that is food for bacteria, including probiotics. Prebiotics are mainly comprised of sugars too complex to be digested by our own bodies, but just right for microbes. Prebiotics also include polyphenols, natural chemicals that act as food for gut bacteria and as antioxidants.

Plants are the best source of prebiotics, while meat contains no dietary fibre. Somewhat confusingly, the prebiotics that feed psychobiotic microbes are also referred to as psychobiotics.

Eating a wide variety of vegetables and berries will give >

"Stress can affect the gut, and then the gut can influence how we deal with stress"



HOW TO CARE FOR YOUR MICROBIOME (AND KEEP IT HEALTHY AS YOU AGE)

Your gut microbiome is a vital support system for mental and physical health, supplying the body with all-important nutrients and helping tune the immune system. And we are now realising how vital this is for healthy ageing too.

As we get older, the balance of microbes in our gut changes. There are declines in beneficial types, such as the anti-inflammatory *Faecalibacterium*, and an increase in species that lead to more inflammation, which is implicated in multiple age-related conditions, including heart disease, cancer and cognitive decline. Many studies, with participants ranging from an isolated rural population in India to a wealthy semi-urban community in Italy, show striking similarities in the microbiome signatures of old age. One key finding is that people who have no significant health concerns in older age have an abundance of distinct beneficial microbes that are lost when there is a shift to physiological decline.

It isn't clear whether the microbiomes of healthy older people are driving their vitality or are a result of the way they live, but an astonishing study in mice by John Cryan at University College Cork, Ireland, and his colleagues found that transplanting gut microbiota from young animals to elderly ones reversed age-associated impairments in brain function.

All this emphasises how crucial it is to look after our gut microbiome and keep it as beneficial as possible. But how exactly should we go about this?

For a start, we need to know what a healthy microbiome looks like. This is no mean feat. "There are no overt physical signs that can be reliably used to tell if your microbiome is health-associated or not," says Paul O'Toole, also at University College Cork.

Even when researchers analyse the myriad different kinds of microbes in our guts, it is hard to work out exactly what is doing what. "Despite the growing science linking the gut microbiome and the chemicals it produces with dozens of health outcomes, what defines an optimum or 'healthy' gut microbiome is still not absolutely clear," says Tim Spector at King's College London, who is a co-founder of personalised nutrition company ZOE.

One of the most common measures of gut health is microbial diversity, with more regarded as better in general. But this isn't foolproof. The problem is that even having many unhealthy bacteria could make the microbiome more diverse, says Spector, so diverse doesn't always mean better. And some groups, including vegans, tend to have a diet rich in plants and have lots of good bacteria, but also have lower diversity, says Spector. Another more recent approach is to analyse the thousands of chemical metabolites of microbial fermentation in the gut, he says, "but we currently don't understand most of their functions, and many changes can be very short term".

To address these issues, the ZOE team joined forces with researchers at the University of Trento in Italy to devise a new measure of microbiome health. It is based on the genomic sequencing of more than 100,000 stool samples sent by ZOE users, which uncovered hundreds of hitherto unknown gut species. This data was then linked to dietary and health patterns to provide a new way to compare the ratio of "good" bacteria to "bad". "This performed much



CHRISTOPHER T STEIN/GETTY IMAGES

Unsurprisingly, diet is key to a healthy microbiome as we age



better than traditional measures of diversity in categorising healthy guts, and for charting improvements with diet," says Spector.

This kind of research is helping to build a better picture of the microbial make-up associated with good health and the factors that influence such a state. Unsurprisingly, diet is key. "Increasing the diversity of the foods we eat increases the diversity of the microbiome," says Cryan.

Feed your gut

To get that diversity, Spector recommends eating a variety of plants, ideally 30 different types per week, as well as "eating the rainbow" – consuming a mix of colourful plants high in substances called polyphenols that are linked with high microbiome diversity. There is also some evidence that fermented foods, such as yoghurt, kefir, kombucha and kimchi, could increase diversity and dampen inflammation – so if you enjoy those, add them to your diet.

Increasing the amount of fibre you consume is also helpful, assuming your digestive system can tolerate it. "Fibre is broken down by lots of microbes and provides lots of key molecules," says Cryan.

There are things to avoid eating too. "Excessive amounts of sweeteners – artificial sweeteners in particular – emulsifiers and ultra-processed foods all have negative effects on the microbiome," says Cryan.

It isn't just what you eat, but when. A number of recent studies show that intermittent fasting can have a beneficial impact on microbiome composition, with knock-on health benefits. For example, one study found that a carefully monitored fast over several days encouraged species of gut microbes that produce beneficial compounds called short-chain fatty acids. In combination with a Mediterranean-style diet, which leans heavily on plant oils, wholegrain foods, fruit and vegetables, this resulted in a greater reduction in blood pressure and weight in people with metabolic syndrome (those who have diabetes, high blood pressure and obesity), compared with the dietary intervention alone. "Give your gut an overnight fast of 12 to 14 hours to help function," recommends Spector.

Other factors have an impact. Our gut microbes are sensitive to stress, for example. Stress can alter the composition of the microbiome, says Cryan. But it is a complex, two-way process. "Stress can affect the gut, and then the gut can impact how we deal with stress," he says. Stress can also cause a "leaky gut" by increasing the permeability of the gut lining, allowing bacteria to enter the bloodstream and trigger inflammation.

Poor sleep can also take a toll on the gut. This is because the microbiome has a daily cycle, says Amita Sehgal at the University of Pennsylvania. "Sleep loss will disrupt rhythms in the microbiome." Even small disruptions to sleeping patterns can have an impact. Spector and the ZOE team, for instance, have found that social jet lag, where a different sleep pattern is adopted at the weekend compared with on weekdays, is associated with increased prevalence of unhelpful gut bacteria.

Your social life – or lack of it – can also help shape the inhabitants of your gut (see "How are our microbiomes shaped by our social relationships?", page 38). We pick up some of our microbes from contact with other people and our surroundings, so isolation can cause our microbiome to become less diverse. In fact, this is thought to be one cause of the lack of microbial diversity associated with unhealthy ageing. "The social microbiome is acquired from family, friends, the environment," says O'Toole. "Don't be afraid to get out there, meet people, work in your yard." ›

you the prebiotics you need. Many of the ills of modern life have accelerated since the advent of processed fast food, which often removes the fibre from key ingredients such as grains to make a lighter, less filling product. That encourages extra consumption, a definite plus for the industry, if not for the consumer. Without sufficient fibre, your good microbes will starve. The diversity of microbes in the gut, which we know is good for health, will also suffer. If you don't get enough veggies, a prebiotic supplement can help, especially a blend of prebiotics to support a diverse microbiota.

Postbiotics

Probiotic microbes, fed by prebiotics, produce two groups of substances that are uniquely beneficial to us: neurotransmitters and short-chain fatty acids. These products of microbial digestion in the gut are known as postbiotics and can profoundly influence our health.

The neurotransmitters produced include dopamine, serotonin and GABA, which are known targets of psychoactive drugs. Your microbes use these substances to talk to each other, but also to you. This grants them the superpower to drive some of your cravings, for better or worse. The vagus nerve communicates these signals from nerve cells lining the gut to the brain, which may play a role in moderating depression and anxiety.

The short-chain fatty acids include butyrate, a molecule that both nourishes and heals the cells lining your gut, preventing microbes from leaking into the bloodstream. Butyrate travels to your brain, where it can stimulate new neuron growth. It also boosts the production of immune cells known as T-cells that act to dampen inflammation. Could you cut out the middle man and just take these substances as supplements? Perhaps in future, but for now, a working microbiome is still the best way to generate these substances on your own. ›





And it is for these reasons that Cryan has one final tip: get a dog if your circumstances allow it. "The other thing that's good for your microbiome is having a pet," he says. One 2022 study of dog owners, for instance, found their pet boosted the composition of their microbiome in positive ways.

The more we learn about the microbes in our gut, the more ways we find to tweak them in a healthy direction. "It's clear from our own and other research that looking after our gut microbiome should be a priority in public health," says Spector.

Alison George

THE GUT MICROBIOME AND CHRONIC DISEASE

One of the most compelling discoveries about the gut microbiome is its influence on the immune system. Between 70 and 80 per cent of immune cells are in the gut, where they are constantly communicating with microbes. This crosstalk helps fight disease, strengthen immune responses and regulate inflammation, our body's first line of defence against infection. Controlling inflammation is critical, as too much damages cells and helps drive chronic illness.

It is no surprise, then, that a growing body of evidence implicates the gut microbiome in various chronic diseases, from arthritis to Alzheimer's. It is still early days, and most of these findings only point to associations. But they raise the possibility that gut microbes may contribute to, or even cause, some of our most intractable conditions, an idea that has already inspired new treatments.

It is now well established that gut microbiomes in people with conditions like multiple sclerosis, type 1 and type 2 diabetes, Parkinson's disease and even asthma differ significantly from those of people without an underlying illness. Two papers published earlier this year showed that people with chronic fatigue syndrome – also known as myalgic encephalomyelitis, or ME/CFS – have less of a gut bacterium called *Faecalibacterium prausnitzii* in their stools. This species produces anti-inflammatory molecules, so a deficit of it could explain the excess inflammation seen in the condition. Low levels of *F. prausnitzii* are also seen in the guts of people with inflammatory bowel disease (IBD), a group of disorders characterised by chronic inflammation of the digestive tract,



"Knowing the role of gut microbes in chronic disease should lead to new treatments"







***Lactobacillus* (purple) in kefir, which could boost the microbiome**

STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY

and in children susceptible to type 1 diabetes.

There are hints that gut bacteria may even be at play in Alzheimer's disease, which seems to be exacerbated by chronic inflammation in the brain. A study of 50 people showed a lower abundance of multiple inflammation-dampening bacteria in the guts of people with Alzheimer's compared with those without it.

Pathogenic gut bacteria can also shift during chronic illness. People with rheumatoid arthritis – a disease in which the immune system mistakenly attacks joints – have greater amounts of *Collinsella aerofaciens* in their stools than those without it. Subsequent studies have found that *C. aerofaciens* increases levels of a pro-inflammatory molecule in human intestinal cells that is known to play a role in rheumatoid arthritis. There are three leading ideas as to why the gut microbiome can become disrupted in chronic disease, says Timothy Sampson at Emory University in Georgia. The first is genetics, which could promote different environments in our guts, he says. For instance, mutations in genes associated with IBD affect interactions between the immune system and the microbiome. In mice predisposed to IBD-like symptoms, those lacking one of these genes, called *NOD2*, were more susceptible to developing signs of the condition.

Post-viral problems

A second explanation is to do with environmental toxins. Previous research has linked exposure to common pesticides with an increased risk of some neurodegenerative diseases like Parkinson's. It is possible these chemicals are also responsible for the microbial disruptions found in those with the condition, says Sampson.

Finally, alterations could be related to a preceding infection. For example, many people with ME/CFS report their symptoms beginning after a viral infection. Such infections may cause lasting disturbances to the gut microbiome that then help drive a chronic disease, says Sampson.

Understanding what leads to disruptions in the balance of our intestinal residents could help answer the more critical question of whether these shifts then propel disease. "One of the difficult challenges is understanding what's coming first. Is the microbiome composition changing prior to the disease diagnosis? Or is it something that arises as the disease progresses?" says Sampson. Studies in animals seem to suggest the former. For instance, Sampson and his colleagues have found that transferring gut microbes from people with Parkinson's disease into mice that are genetically predisposed to symptoms of the condition significantly impaired the motor functions of the animals. He and his team have also shown that, in mice susceptible to Alzheimer's-like disease, those without a gut microbiome have fewer of the disease's characteristic protein clumps and tangles in their brains than those with gut microbes.

Whether these animal studies translate to humans is an important next step. One way of testing such ideas in people is by performing faecal transplants from a healthy individual to one with a chronic disease. If symptoms of the disease lessen afterwards, it indicates that the microbiome was driving pathology in some way. Very few of these studies have been conducted, and so far most of those focused on IBD, but their results are promising. Across 36 studies in people with the condition, faecal transplants led to remission in 37 per cent of participants and improvements in 54 per cent.

Understanding how gut microbes contribute to chronic disease may lead to other, more practical ways of treating such illnesses. Taking probiotics, which are foods or supplements that contain beneficial live microbes, or consuming a diet that supports beneficial, anti-inflammatory bacteria could help alleviate symptoms of inflammation, for instance. Alternatively, new medications that somehow alter the workings of the microbiome could do the trick. Already, Stanley Hazen at the Cleveland Clinic, a healthcare institute in Ohio, and his colleagues have developed an oral drug that prevents microbes from producing a molecule called trimethylamine N-oxide, or TMAO, a known driver of heart disease.

"Even if the microbiome itself is not contributing to [chronic disease], by acting on it through drugs or probiotics, we can make the microbiome promote a beneficial function," says Sampson.

Grace Wade





HOW ARE OUR MICROBIOMES SHAPED BY OUR SOCIAL RELATIONSHIPS?

When we are born, we get most of our gut microbes from our mothers (see "Where does your gut microbiome really come from?", page 32). But as we get older and form other close relationships, including with intimate partners, friends and pets, we start to pick up their microbes too. This could potentially affect our risk of developing conditions like obesity, inflammatory bowel disease, asthma and allergies (see "The gut microbiome and chronic disease", page 36).

"I jokingly say that your dating app profile should include your microbiome profile," says Brett Finlay at the University of British Columbia in Canada.

The strongest evidence comes from work published in January by Mireia Valles-Colomer at the University of Trento, Italy, and her colleagues, who conducted the largest study to date of how our gut microbiomes are shaped by the people around us. They analysed DNA in the faeces of more than 7000 people from households around the world, including rural parts of Africa and South America and cities in the US, Europe and China, to find out which bacterial strains were in their guts and what proportion they shared with others.

Bacterial strains are slight genetic variants of the same bacterial species and are highly individualised, meaning if two people share a strain, it must have been directly transmitted between them. As expected, infants under the age of 1 and their mothers shared the most strains of gut bacteria: about 50 per cent. But by the time children reached the age of 3, they only shared 27 per cent of strains with their mothers and an increasing contribution came from other household members, such as their fathers or siblings.

Adults that lived under the same roof – including partners – shared 12 per cent of strains with each other, and even those living in the same village shared 8 per cent. In contrast, people who didn't live together or in the same village shared none.

It makes sense that people cohabiting or living in the same small communities would share gut microbes, since they can be spread by kissing, shaking hands and eating food prepared by others, says Valles-Colomer. One study, for example, found that couples exchange 80 million bacteria


CATHERINE FALLS COMMERCIAL/GETTY IMAGES

on average during a 10-second intimate kiss.

This raises the question of whether we may be able to "catch" conditions that are associated with microbial upsets, like obesity and inflammatory bowel disease (IBD), from our nearest and dearest. We know from previous research that having a spouse, close friend or sibling who becomes obese raises our chance of becoming obese by over 37 per cent, and that marrying someone with IBD increases our risk of developing it ourselves.

It is hard to know whether this is simply due to shared lifestyle factors or whether the exchange of gut microbes also plays a role. But evidence for the latter comes from experiments in mice showing that they start to gain weight and develop gut inflammation after receiving transplants of gut microbes from people with obesity and inflammatory bowel disease respectively.

Could the same also be true of microbes we pick up from having pets around? In 2017, an analysis of faeces from more than 700 infants aged 3 to 4 months in Canada found that those with a dog or cat at home had higher levels of *Oscillospira* and *Ruminococcus* bacteria in their guts, both of which are associated with reduced incidence of the likes of asthma and obesity.

This microbe transfer may explain why other studies have found that exposure to

Faecal transplants

If fiddling with your gut microbes to get a perfect internal ecosystem doesn't work for you, there is the nuclear option: a faecal microbial transplant.

Here, your poorly working microbes are wiped out by antibiotics and then faecal matter from a donor with no major health conditions is inserted via an enema. Your gut microbes are like a fully fledged organ in your body, so this is akin to an organ transplant.

As unpleasant as it may sound, it is a godsend for people with hospital-acquired *Clostridium difficile* infections, with a 90 per cent cure rate. The connection between the gut and the brain implies that your faecal donor should not only be healthy, but happy as well.

For now, faecal transplants are only approved for *C. difficile* infections, not simply a bad gut or other conditions. Despite this, advances are being made, including an oral version of such transplants, known affectionately as a "crapsule".

Scott Anderson



We share more with our pets than a roof and four walls

DOES THE GUT MICROBIOME INFLUENCE BODY WEIGHT?

The idea that the microbes in our guts may directly influence our body weight came to the fore in 2006, when Jeffrey Gordon at Washington University in St Louis, Missouri, and his colleagues showed that lean mice bred without any gut microbes – so-called "germ-free" mice – gained more body fat when they were given gut microbes taken from obese mice than those taken from lean mice.

In 2013, Gordon's team unveiled further proof by transplanting the gut microbes of pairs of identical human twins – in each pair one was obese and the other lean – into germ-free mice. They showed that the animals given the microbes from obese twins gained more fat mass.

"Microbial activity plays an important role in both energy harvesting and in regulation of energy balance", says Andrew Holmes at the University of Sydney in Australia. That is because gut microbes are the only way we can get energy from fibre in our diet, and they also influence hormones that help us to feel full.

The findings made others wonder if obesity in people could be treated by recolonising their guts with microbes taken from lean individuals via faecal transplants. However, several clinical trials set up to test this have had disappointing results.

One reason why is that it is harder to seed new gut microbes in people with established microbiomes than in germ-free mice, says Holmes. "It's like trying to change a savannah to a rainforest by dumping 20,000 tonnes of rainforest seeds on top – you might introduce some new species, but you're definitely not going to turn it into a rainforest."

What's more, there are many other factors involved in body weight, including genetics and diet.

In the future, we might be able to identify the most effective weight-loss strategies for individuals with obesity by analysing their microbiomes in combination with genetics and diet.

AK

a dog in infancy is linked with a lower risk of developing asthma, eczema, food allergies and obesity, says Finlay, although a causal link is yet to be established. Either way, it is clear that we are sharing a lot more with our housemates than a roof and four walls.

Alice Klein

COULD WE EVER MAKE DESIGNER MICROBIOMES?

When it comes to altering our microbiome, the aim is simple. We want more beneficial microbes and fewer harmful ones. But achieving this isn't easy.

If people ingest beneficial strains of microbes, often called probiotics, they usually die out rather than becoming established in the gut. And antibiotics, the main tool we have for killing off harmful microbes, such as the ulcer-causing *Helicobacter pylori*, are blunt weapons. They also kill many beneficial bacteria, resulting in side effects such as nausea and diarrhoea.

As a result, many teams worldwide are working on more precise ways of altering our gut microbiota. The simplest is to harness viruses that naturally infect bacteria.

Our guts are already teeming with so-called bacteriophage viruses, also known simply as phages. There can be more than a billion of them per gram of faeces. By finding and dosing people with viruses that kill specific bacterial strains, the numbers of those bacteria can be reduced. For instance, phages have been used to kill off bacterial strains associated with inflammatory bowel disease, though only in people without IBD so far.

Another approach is to use weapons based on CRISPR gene-editing technology. This method has been used to kill dangerous bacteria in the guts of mice, but hasn't yet been tried in people. Such weapons can even delete undesirable genes from bacteria without killing them, such as the genes for toxins that make some strains harmful.

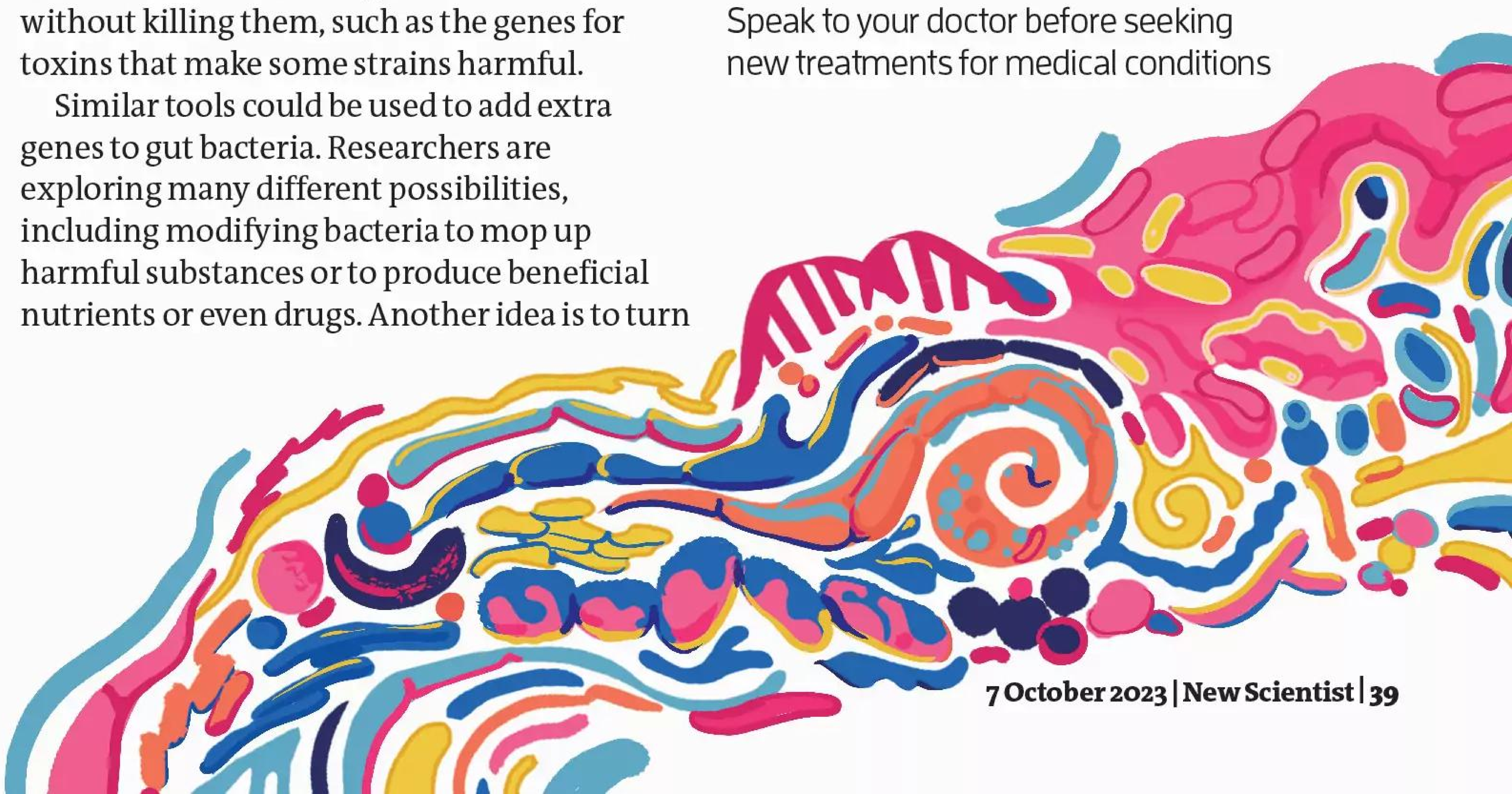
Similar tools could be used to add extra genes to gut bacteria. Researchers are exploring many different possibilities, including modifying bacteria to mop up harmful substances or to produce beneficial nutrients or even drugs. Another idea is to turn bacteria into living sensors for the early detection of diseases such as cancer.

However, these ideas involve creating genetically modified organisms that might spread to other people. One answer to this is to make modified bacteria dependent on nutrients not found naturally, so they can survive only in the guts of people who feed the bacteria by regularly taking pills containing those artificial nutrients.

Even so, regulators are going to need a lot of convincing of the benefits and safety before giving the go-ahead for this kind of approach. ∎

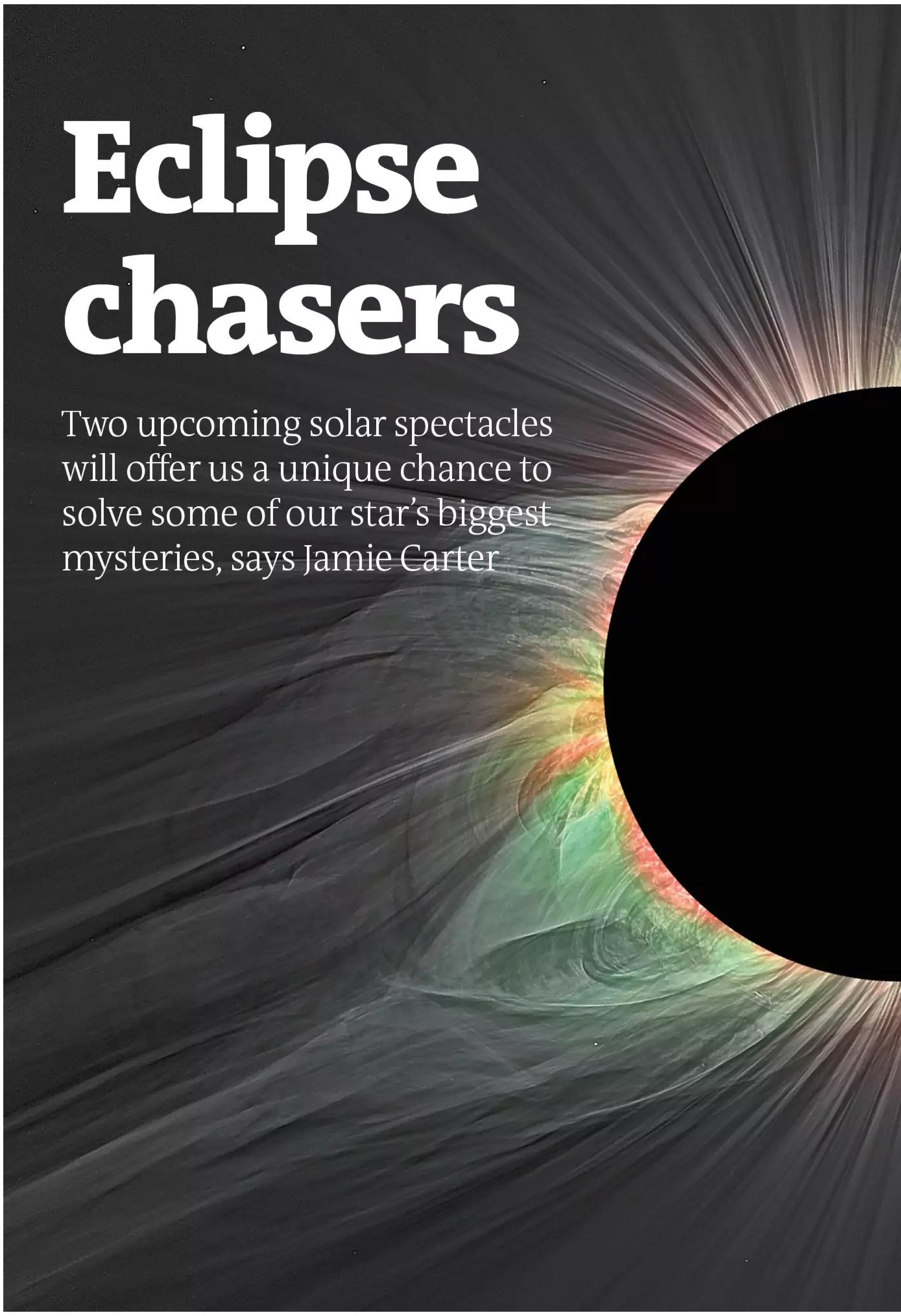
Michael Le Page

Speak to your doctor before seeking new treatments for medical conditions



Eclipse chasers

Two upcoming solar spectacles will offer us a unique chance to solve some of our star's biggest mysteries, says Jamie Carter



S. HABBAL/M. DRUCKMÜLLER/NASA

IN AUGUST 2017, scientists sailed a boat off South Carolina equipped with a weather balloon. The plan was to float it above the clouds for a guaranteed view of an impending total solar eclipse. Then, a terrible storm struck. "They were mostly trying to keep the boat from capsizing," says Angela Des Jardins, a physicist at Montana State University who leads the Nationwide Eclipse Ballooning Project.

The team behind this project had launched 55 balloons across the US in total. As these popped and parachuted back to Earth, many got caught in trees. It took weeks to get them back. "This time," says Des Jardins, "we're giving everyone a special tree pole."

After a six-year wait, the next total solar eclipse over the US is almost here. First comes a practice run. On 14 October, an annular solar eclipse will see almost all of the sun blocked by the moon, leaving just a "ring of fire". Then, on 8 April 2024, the real deal arrives – a total eclipse visible over a narrow strip of North America.

Both offer a chance to see part of the sun usually hidden from view: its wispy, mysterious outer atmosphere, known as the corona. This is the birthplace of the solar wind that travels through our patch of space, sometimes causing aurorae and disrupting satellites. But we understand very little about it. The coming eclipses offer a unique, if fleeting, opportunity to study it. Over the past few years, researchers have been diligently preparing so that, when the time comes, they are ready. That time is now.

It is a quirk of our solar system that the moon and the sun can appear to be the exact same size in the sky. On average, the moon is 400 times closer than the sun while also being 400 times smaller. This cosmic coincidence is what gives us the phenomenon of a solar eclipse, when light from the sun is blocked by the moon.

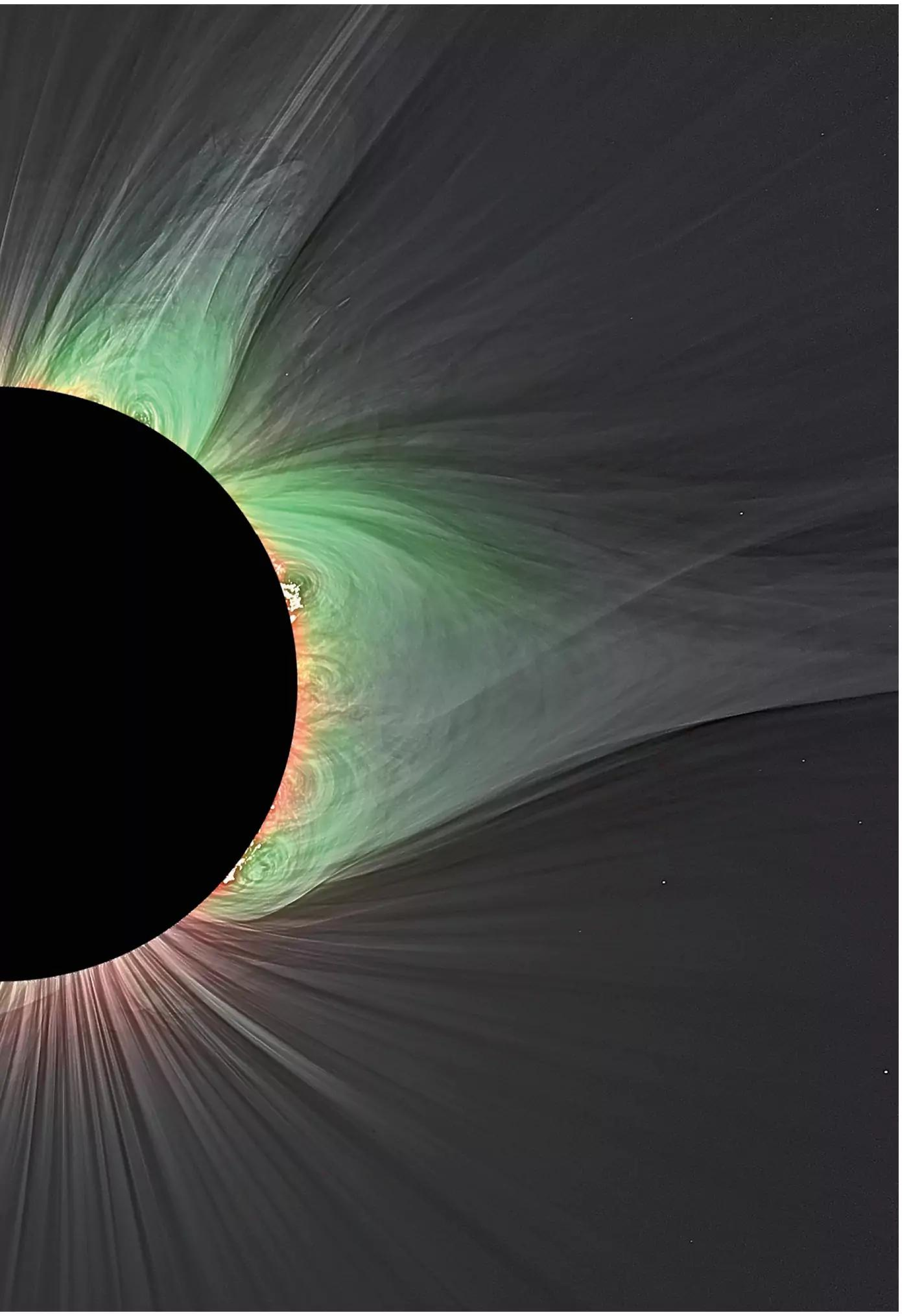
Solar eclipses come in many forms. They can be partial, where only some of the sun is blocked: an annular eclipse is a special kind of partial eclipse. Or they can be total, in which the moon fully covers the sun's disc blocking its light in its entirety from our point of view. These are the most dramatic to watch… and the most fruitful for research.

For more than 150 years, these events have provided opportunities for scientific discovery. It was while viewing a total solar eclipse in Guntur, India, in 1868 that astronomer Pierre-Jules Janssen noticed a bright yellow light that had to be coming from an element not yet identified on Earth. It was ultimately named helium, after Helios, the Greek god of the sun.

But perhaps the most famous total solar eclipse came in 1919, when astronomers Arthur Eddington and Frank Watson Dyson went to Sobral in Brazil and to Príncipe Island in the then Portuguese colony of São Tomé and Príncipe just off the coast of Gabon. They studied the positions of stars and planets that became visible in the day during the fleeting time that the moon was blocking the sun's light, confirming that they appeared to shift in the sky. This was the first evidence of gravitational lensing, when large bodies bend light from distant objects, and confirmation of Albert Einstein's general theory of relativity, which was published just a few years earlier.

A century later, during a total eclipse in 2019, gravity once again took centre stage. This time, researchers were hunting for gravity waves – not to be confused with gravitational waves, which are ripples in space-time. "Gravity waves are perturbations in the atmosphere generated by mountain ranges and by day and night temperature differences," says Des Jardins.

It was first suggested in the 1970s that the cold, dark shadow of a total solar eclipse



Filtered photos of the sun during an eclipse reveal stunning colours

“During totality, we see plasma trapped along the sun’s magnetic field, like iron filings near a magnet”

would generate visible gravity waves high up in the atmosphere, she says. But this had never been observed in the stratosphere. That changed with the 2019 event, when a ballooning team led by Thomas Colligan at the University of Montana recorded them from Chile. Unfortunately, the researchers didn’t manage to get any images – but that is something Des Jardins is hoping for with the upcoming eclipses. “There’s definitely a chance we’ll be able to see gravity waves,” she says. “We’re hoping the balloons will bob along the gravity waves at 90,000 feet [27,432 metres].”

Expectations are sky high for the April eclipse because totality – when the sun is entirely covered – will last up to 4 minutes and 27 seconds – the longest such period on land for over a decade. “The colder, the darker and the longer the change, the higher chance there is of gravity waves,” says Des Jardins.

But the main reason why solar scientists will be studying April’s event is to view the strangest part of the sun: the corona. Seen fleetingly as a bright halo that appears only during totality, it is a million times dimmer than the rest of the sun in visible light. The corona is also a million degrees hotter than the sun’s surface (the photosphere – which reaches only about 6000°C) and it extends millions of kilometres into the solar system.

The corona is where the sun’s magnetic fields act on charged particles to form complex shapes, known as streamers, loops and plumes, among other names. Understanding the corona will help us predict the solar wind, the stream of charged particles hurled from the sun into space. This is what causes aurorae, but it is also a potential threat to astronauts, satellites and electricity grids.

Shadia Habbal, a solar researcher at the University of Hawaii Institute for Astronomy, has been chasing solar eclipses for almost 30 years, using special filters and cameras to measure the temperatures of the particles from the innermost part of the corona.
It isn’t always glamorous. In 1995, for example, armed with one of the first digital cameras, Habbal and her team arrived at what seemed a hospitable site near Jaipur, India, to view a 42-second eclipse. “We stayed in elaborate, decorated tents each with toilets and sinks,” ›

New Scientist Discovery Tours
Watch the 2024 total eclipse from a secluded ranch in Texas newscientist.com/tours



AMIR CASPI/NASA'S GODDARD SPACE FLIGHT CENTER

she says. "But in the morning we discovered that the sewage was right outside the tent."

Since then, Habbal's group, now known as the Solar Wind Sherpas, has travelled to places as far afield as the Marshall Islands, Kenya, Mongolia, the Norwegian archipelago of Svalbard, Antarctica and Libya. At each eclipse, some of which last just a few seconds, Habbal and her team image the corona using their filters. Studying the different wavelengths of light emitted by charged iron particles in the corona lets them tease out temperatures.

Most of the time, solar physicists studying the corona rely on coronagraphs on space-based observatories, which use a disc on a telescope to block the sun. But these devices cover up the innermost part of the corona, the source of towers of plasma called prominences and eruptions called coronal mass ejections.

"Observations during totality are critical," says Habbal. There is no other way to see the part of the sun's atmosphere that extends from its surface out to at least five solar radii in a continuous manner. "That's fundamental to understanding how the solar atmosphere starts at the sun and then extends into interplanetary space," she says. Only then can accurate computer models be devised that simulate the corona and help in the prediction of space weather.

In the past couple of years, Habbal's group has made an astonishing discovery. Right now, the sun is heading towards solar maximum in 2025, the most active point in its 11-year cycle, when the solar wind intensifies. Since the corona looks much larger during total solar eclipses at solar maximum, it was thought that the solar cycle and the temperature of the corona are inextricably linked. But it might not be so simple. In 2021, Habbal and her colleagues published research from observations taken during 14 total solar eclipses that suggests the corona's temperature isn't dependent on the solar cycle. The lines of the sun's magnetic field can be open, travelling outwards with the solar wind, or closed, which are hotter and form loops. "We found open field lines everywhere regardless of the cycle," says Habbal. This means the corona has a roughly constant temperature.

Bad weather has prevented observations since 2019. "We had rain in Chile in 2020, clouds at sea in Antarctica in 2021 and there was no eclipse in 2022," says Habbal. It was during the expedition to Antarctica that team member Benedikt Justen suggested that next time they could fly a kite equipped with a spectrometer, which separates light into its component wavelengths.

> **"Nature has handed us a wonderful set of eclipses"**

The NASA-funded kite, which has a 6.5-metre wingspan, was successfully tested in Western Australia during a total solar eclipse in April this year. It was launched on a kilometre-long tether attached to a vehicle. "It was pretty miraculous," says Habbal. Bad weather meant that the team flew it for the first time just 45 minutes before totality. "It was thrilling."

If the technology works well at the US eclipse next April, the kite will be deployed more in future, probably with cameras added. "It's much easier and cheaper than using balloons," says Habbal. But if it doesn't work, there is always a back-up.

The Solar Wind Sherpas are also planning to observe the eclipse remotely from more than 18 kilometres above the Pacific coast of Mexico, clear of any clouds, thanks to two of NASA's high-altitude research aircraft. During the total eclipse, two WB-57 planes will follow each other at 740 kilometres per hour, about a quarter of the speed of the moon's shadow, just south-



KLEMENS BRUMANN AND BENEDICT JUSTEN



KELLY GORHAM/MONTANA STATE UNIVERSITY

A kite (far left) and weather balloons (left) will observe the April 2024 event



NASA's WB-57 planes can fly very high in Earth's atmosphere

west of the maximum point of the eclipse. At that speed, totality increases from the 4 minutes 27 seconds for those viewing it from the ground to over 6 minutes. "The WB-57 is perfect for this because in its nose cone is a camera and telescope system that can rotate to point at anything… no matter which way the aircraft is flying," says Amir Caspi at the Southwest Research Institute in Boulder, Colorado, who is in charge of an experiment in the second WB-57 to study the corona in a different way.

Using a stabilised platform, Caspi and his team will capture images of the eclipse using both a visible light camera and a higher-resolution mid-infrared camera developed by NASA. The latter will capture seven different wavelengths of light and help determine which structures in the corona emit their own light and which merely scatter light from the sun's surface. "We need to be above as much of the atmosphere as we can get to make those observations," says Caspi. Infrared light is absorbed by Earth's atmosphere and is hard to observe from ground level.

Caspi is also part of the Citizen Continental-America Telescopic Eclipse (CATE) project, an attempt to make a continuous 60-minute high-resolution movie using 35 teams of citizen scientists in the path of totality, from Texas to Maine, each with exactly the same cameras, telescopes and training so they can make exactly the same kinds of observations. "The teams will be spaced out so that every station is overlapped by its neighbours," says Caspi. "If one station doesn't get data, because of clouds or broken equipment, it's OK."

Coronal complexities

He is hopeful the equipment will work, since it was successfully tested earlier this year in Western Australia. "That was the first eclipse I've seen," says Caspi, who only got to see a few brief seconds because he was busy live streaming it on YouTube. "Our equipment couldn't get online so I spent the whole time holding my phone in front of my face."

The movie will hopefully allow scientists to study the corona's complexities, notably its shape and how it changes over a short time. It builds on a CATE project from 2017, which used 68 cameras throughout the path. This time, it will use more sophisticated cameras that are sensitive to different types of polarised light.

"Most of the light that you see during totality is actually light from the surface of the sun that goes up into the corona to scatter off electrons," says Caspi. This is the K corona, the bright inner part, which overwhelms the light coming only from the corona itself. As the light scatters, it becomes angled, a property called polarisation. "If you can measure the angle of polarisation, then that gives you a 3D structure of the corona, its density and how that changes over time," he says.

Time is in short supply during a total solar eclipse, so a continuous hour-long video makes it possible to capture processes that take seconds or minutes, like a solar flare or coronal mass ejection, as well as other details. "The corona is permeated by a complicated magnetic field," says Caspi. "During totality, we don't see the magnetic field, but instead the hot plasma trapped along it – just like being able to see iron filings around a magnetic field around a magnet."

Meanwhile, the researchers behind the original CATE project in 2017 are now working on another broadcast. The aim of the Dynamic Eclipse Broadcast (DEB) is to produce a live continuous broadcast of the solar corona. "This time we're using smaller cameras and telescopes with a wider field of view to image more of the corona," says Bob Baer at Southern Illinois University.

And it isn't just the sun they are interested in. During next week's annular eclipse, 48 DEB teams will be studying the shape of mountains on the moon, by measuring how light shines through the peaks as the edge of the moon passes across the sun's disk. As part of this, 20 teams of girls aged 11 to 13 will be equipped with telescopes and trained how to use them. Even if it is cloudy, they will get to keep the telescopes after.

Still, next week, and again in April, scientists across the US will be hoping for a clear view. Never before has there been a chance to compare what happens during two different kinds of eclipses, one with a deep moon shadow and one where a very large portion of the sun is obscured. "Nature has handed us a wonderful set of eclipses six months apart, in our own country," says Des Jardins. "No one's ever done anything like this." ▮

Look out for more coverage of the US eclipses at newscientist.com



Jamie Carter is a freelance journalist based in the UK

Puzzles
Try our crossword, quick quiz and logic puzzle p45

***Almost* the last word**
When did we realise moonlight is reflected sunlight? p46

Tom Gauld for *New Scientist*
A cartoonist's take on the world p47

Feedback
Black Hole Lane, rauk rocks and the work of Boris Worm p48

Twisteddoodles for *New Scientist*
Picturing the lighter side of life p48

The science of cooking

All white, alright?

Chicken changes colour when it is safely cooked, right? Not always – and clear juices can't be relied on either, says **Sam Wong**



Sam Wong is assistant news editor and self-appointed chief gourmand at *New Scientist*. Follow him @samwong1

What you need

2 chicken breasts
Salt
A kitchen thermometer

The science of cooking appears every four weeks. Share your cooking successes with us on Twitter and Instagram @newscientist, using the hashtag #NewScientistCooking

Next week

60-second psychology

HOW do you know when a piece of chicken is cooked? Most people think you can tell by looking at the colour, but it turns out this isn't reliable.

Chicken is one of the riskiest foods for *Salmonella* and *Campylobacter*, two of the biggest causes of food-borne illness. These bacteria can be found on the inside of chicken meat, which is why chicken must be cooked through, unlike beef.

Muscle tissue changes colour when myoglobin, an oxygen-binding pigment similar to haemoglobin, is denatured. Chicken muscle, however, contains less myoglobin than most other kinds of meat, so the colour change is less pronounced – and recent research shows that it happens before harmful bacteria have been eliminated.



THE FOODIE/ALAMY

In a 2020 study, Solveig Langsrud at the Norwegian Institute of Food, Fisheries and Aquaculture and her colleagues injected chicken breast fillets with *Salmonella* and *Campylobacter*. They cooked the fillets between two grill plates until they reached core temperatures between 50 and 70°C (122 and 158°F). Samples from the core and the surface of the meat were taken for analysis.

According to guidelines from the World Health Organization, chicken should be cooked to 70°C in order to be safe. But the team found that most of the colour change happened below 55°C (131°F). Clear juices can't be relied on either: even at 50°C, the colour of the fluid was too pale for the instrument to detect.

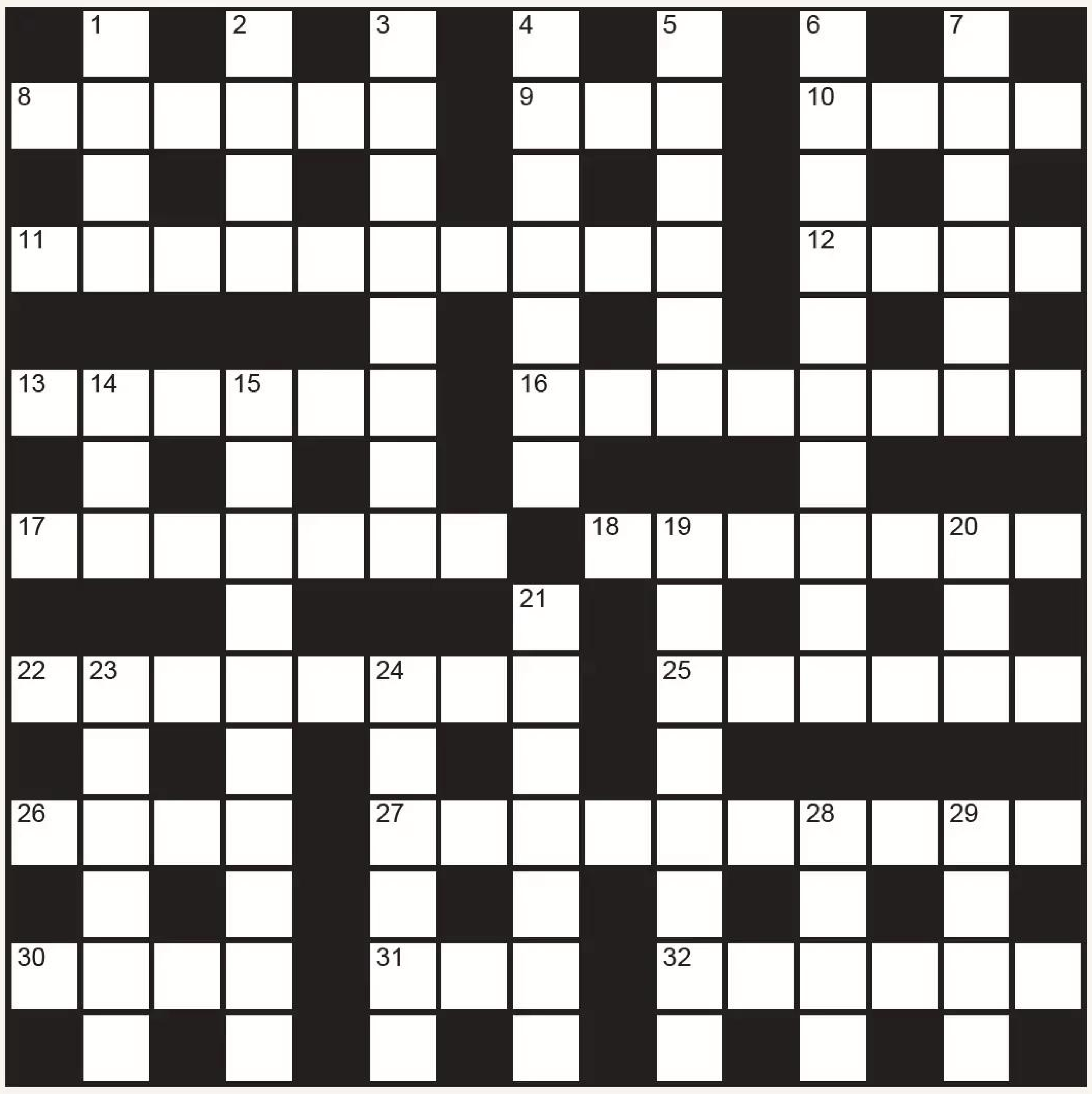
Using a kitchen thermometer can help make sure food is safe, but there are problems with this method too. Langsrud and her team tested five thermometers marketed at consumers. All but the cheapest one were reasonably accurate, but even the more expensive ones took between 4 and 15 seconds to give an accurate reading. You also have to test the meat in several places to make sure you have found the coldest part.

Worryingly, even when the core temperature of the fillets reached 70°C, some bacteria survived on the surface of the sides of the meat, which weren't in contact with the grill plate. Langsrud says bacteria are found in higher numbers on the surface of meat than the interior, so the most important thing is to make sure that chicken is cooked on all sides. "I would guess that when people get sick, it's most often because they eat something that's partly raw on the outside," she says.

Perhaps the safest ways to cook chicken, then, are those in which the meat is braised in a sauce or poached in water. To poach two chicken breasts, cover them with cold water in a saucepan with a tablespoon of salt. Bring to a simmer, keep it simmering for 10 minutes, then turn off the heat. Flip the breasts over, cover with a lid and leave for 15 minutes. Ideally, check the core temperature with a good thermometer. ▮

These articles are posted each week at newscientist.com/maker

Quick crossword #143 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

8 New World flycatcher (6)
9 Flying saucer, possibly (3)
10 Scientific premises (4)
11 Constellation that contains the dog star (5,5)
12 Geneva-based research organisation (4)
13 Reciprocating engine component (6)
16 Rigid boundary surrounding cytoplasm (4,4)
17 One who carries out a systematic study (7)
18 Painkiller (7)
22 Collarbone (8)
25 ___ Observatory, historic research base in Arizona (6)
26 Terminal orifice of the bowel (4)
27 Laryngeal prominence (5,5)
30 Danish construction toy (4)
31 Component of the psyche, in Freudian terms (3)
32 Astringent compound found in oak trees (6)

DOWN

1 Plant in the mint family, cultivated for its seeds (4)
2 Search for extraterrestrial intelligence (4)
3 Puzzle video game first published in 1991 (8)
4 Research participant (7)
5 Grassland plant with edible leaves (6)
6 Spider in the genus *Latrodectus* (5,5)
7 Closer to the 26 Across than to the mouth (6)
14 Charged particle (3)
15 Entertainment technology invented in the 1920s (10)
19 Collection of numbers with a Lebesgue measure of zero (4,4)
20 O (3)
21 Unit of explosive power (7)
23 *The* ___, medical journal founded in 1823 (6)
24 Impact hole (6)
28 1972 arcade game (4)
29 ___ Alvarez, Nobel-winning physicist (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #222
set by Bethan Ackerley

1 In biology, what does ATP stand for?

2 In astronomy, what does FRB stand for?

3 In computing, what does ASCII stand for?

4 In medicine, what does BCG stand for?

5 In chemistry, what does DDT stand for?

Answers on page 47

Headscratcher
set by Rob Eastaway
#242 Filling up in Pumpstown

When I drive south through Pumpstown, I always need to fill up the car at one of the three gas stations (North, Mid or South) that are strung along the freeway that passes through the town.

Of course, I want to get the best possible deal: there is nothing worse than filling the tank only to find I would have got cheaper fuel if I had waited until the next station. It is a busy road and there is no turning back, so if I haven't filled up before getting to South, I have to get fuel there even if it is the most expensive.

I have been studying the pricing patterns, and I have found that the three stations always charge different prices from each other, but it seems to be random as to which station will have the cheapest fuel in a particular week. I have also noticed that prices fluctuate a lot from day to day.

Today, as the North station heaves into view, I notice that it is selling at 5.83 Ruritanian dollars per litre. If I fill up there, then there is a 1 in 3 chance it will be the cheapest.

Is there a way that I can improve my odds?

Solution next week

Moonlight spotlight

When was it first realised that the lit portion of the moon always faces the sun, so moonlight must be reflected sunlight?

***James Ladyman**, University of Bristol, UK;* ***Kelli Rudolf**, University of Kent, UK*

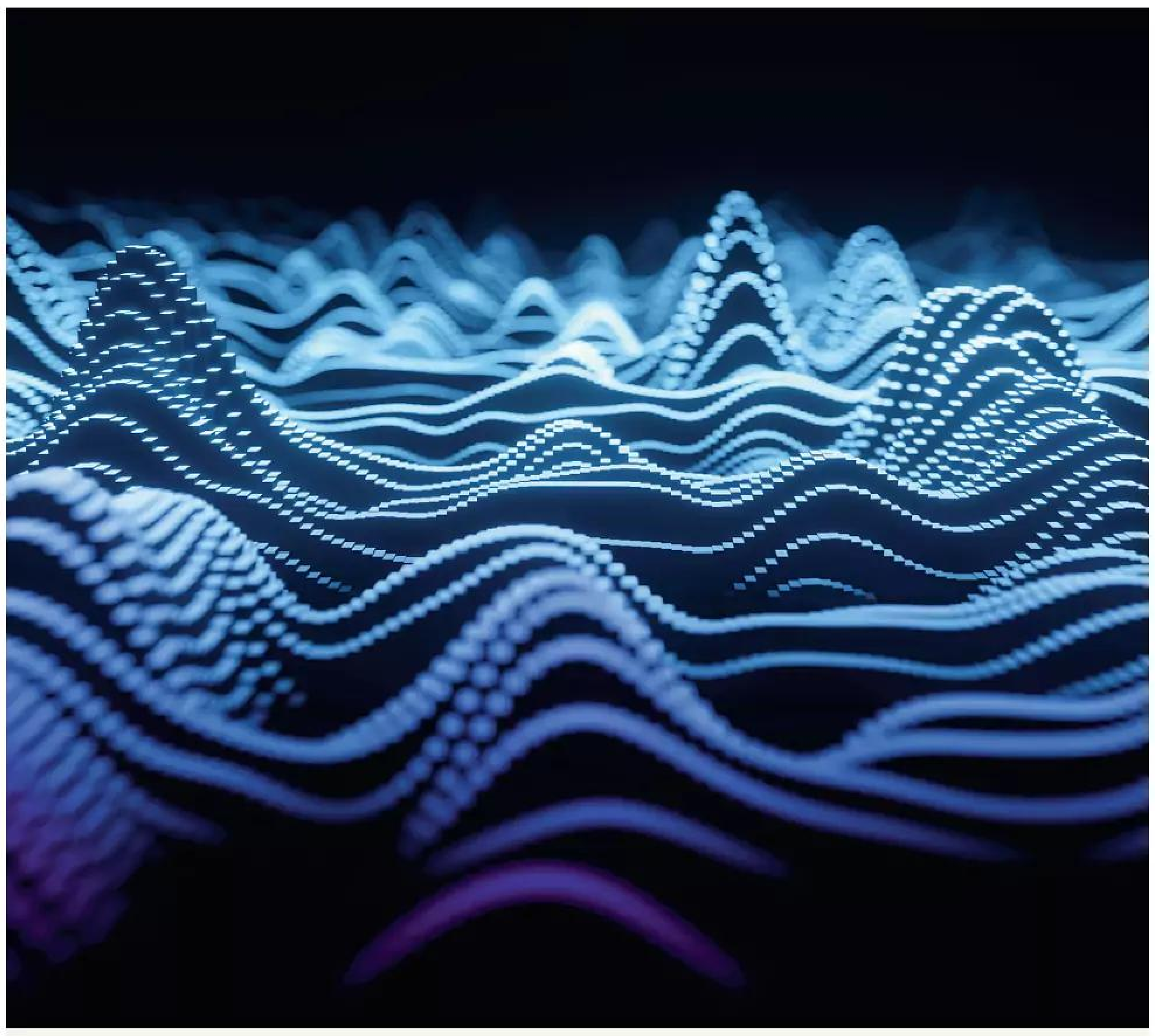
Thinking about how objects can shine with reflected light, such as the way oil, water, metal or the eye reflect light when illuminated in the dark, is likely to have led many people over the ages to the conclusion that the moon doesn't shine on its own.

We can't even know for sure who first wrote this idea down because so many ancient philosophical texts are lost. However, we do know that Anaxagoras was one of the first to do so because a fragment of his writings translates as "the sun indues the moon with brightness" (it was hinted at a little earlier by Parmenides, who said the moon is a "night-shining, foreign light, wandering around the Earth").

> "Anaxagoras, born around 500 BC, was eventually exiled from Athens for denying that the moon and the sun are gods"

Anaxagoras was born in approximately 500 BC in Clazomenae in Ionia (which is now in Turkey and was then part of the Persian Empire). He moved to Athens, from where he was eventually exiled for denying that the moon and the sun are gods. He thought that Earth was a flat disc, but his ideas about the moon and the sun led him to the correct explanation for eclipses, and he also claimed correctly that there are mountains on the moon.

That the same side of the moon always faces Earth is apparent by observation, especially with a telescope. The reason for this is gravitational tidal locking, which was first posited by Isaac Newton. A little more than half the moon's surface is visible from Earth at different times.



What happens to the energy from sound generated around the world?

FLAVIO COELHO/MOMENT RF/GETTY IMAGES

This week's new questions

Sound off **A huge amount of sound is generated in the world, which takes energy. As the sound dissipates, what happens to this energy?** ***John Still**, Portpatrick, Dumfries and Galloway, UK*

Plunging in **When going swimming in the sea, is it better (scientifically, emotionally or spiritually) to enter quickly or to take your time?** ***Derek Long**, Cambridge, UK*

Cold spell

If a northern hemisphere "ice age" is triggered, say due to the Gulf Stream failing, is it inevitable in the southern hemisphere too?

Peter Bursztyn
Barrie, Ontario, Canada

No. A northern hemisphere "ice age" won't trigger widespread glaciation in the southern hemisphere.

Changing geography made glaciation possible across the Arctic, Eurasia and North America.

The Arctic Ocean was relatively ice-free until continental drift gradually enclosed it. Today, the narrow Bering Strait keeps the North Pacific current out of the Arctic Ocean. Instead, it warms the southern coast of Alaska, keeping it ice-free. Similarly, Baffin Island and Greenland deflect the Gulf Stream, preventing its warmth from reaching the Arctic Ocean. Instead, it keeps Norway's west coast relatively clear of ice.

On the other hand, it is also virtually impossible for ocean ice to spread north from Antarctica. Various oceanic currents inject tropical warm water continuously into the Southern Ocean. This body of water swirls around Antarctica, limiting the growth of its ice shelves.

Researchers have devised indirect methods to detect past glaciations. These are based on measurements of the relative abundance of two oxygen isotopes: oxygen-18 and oxygen-16. Most oxygen is oxygen-16, but some is oxygen-18 (with two extra neutrons), which evaporates slightly more slowly. As global temperatures fall during a glacial period, the ratio of the isotopes in precipitation changes, creating a "chemical thermometer". These isotopes can be detected in ice cores drilled out of ice sheets.

Greenland's ice is only 180,000 to 200,000 years old. However, Antarctic ice dates back around 800,000 years! Earth is apparently due for another glacial period soon, but warming caused by human carbon dioxide emissions means this is unlikely to occur.

Mike Follows
Sutton Coldfield, West Midlands, UK

At the equator, the sun is higher in the sky, so sunlight is more intense there than at the poles. This makes the equator hotter. Heat moves from hotter to colder places, so convection currents in the atmosphere and the oceans move heat from the equator towards the poles. In the oceans, this movement is known as the thermohaline circulation. As its name suggests, it is driven by differences in the temperature and salinity of the water.

The section between the Gulf of Mexico and the North Atlantic is known as the Atlantic meridional overturning circulation (AMOC), and it keeps western Europe about 5°C (9°F) warmer than it would otherwise be. The surface waters, known as the Gulf Stream, flow northwards, while water on the ocean floor flows south. As it travels, evaporation from the surface of the Gulf Stream leaves the water colder and saltier and therefore dense enough to sink when it reaches latitudes around Iceland (before heading south along the ocean floor).

The worry is that the Greenland

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Tom Gauld
for New Scientist



ice sheets will melt as a result of global warming. This fresh water will dilute the salty water so that it will no longer be dense enough to sink. This will weaken or halt the AMOC and western Europe will end up colder in a world that is warming. Indeed, it may lead to temporary global cooling.

Something like this has happened in the past. Earth has been experiencing the Late Cenozoic Ice Age for the past 34 million years. The latest phase of this is the Quaternary Period, during which Earth has switched between relatively cold (glacial) and relatively warm (interglacial) states. The glacial periods are sometimes confused for "ice ages".

At the peak of the last glacial period, North America was partly covered by the massive Laurentide ice sheet. As Earth warmed, the meltwater created Lake Agassiz, a huge glacial lake in central North America. Some think that when this lake drained into the Arctic Ocean about 12,000 years ago, it caused the thermohaline circulation to stop abruptly. The

"When Lake Agassiz drained into the Arctic Ocean 12,000 years ago, the thermohaline circulation may have stopped abruptly"

temperature didn't fall as quickly as portrayed in the 2004 film *The Day After Tomorrow*, but what is known as the Younger Dryas event took place over the lifetime of humans who were unfortunate enough to live through it. The average temperature of the UK fell to -5°C (23°F) during this time.

There is growing evidence that the AMOC is weakening, and a *Nature* paper published in March has reported evidence of a similar thing happening in the Antarctic. Interestingly, work by a team of researchers led by Raphael Neukom at the University of Bern suggests that the temperatures in the two hemispheres of Earth don't always stay in lockstep. For example, the so-called Little Ice Age experienced in Europe between 1650 and 1750 took place centuries apart in different regions of Earth.

However, it seems inconceivable that the two hemispheres could develop totally independent climates. I am reminded of the novel *On the Beach* by Nevil Shute, where the radioactive fallout from a nuclear war in the northern hemisphere diffused towards survivors in Australia.

Two of a kind

How do dogs recognise that another animal is also a dog when there is such a vast array of canine shapes and sizes? (continued)

Ian Watson
Glasgow, UK

In support of previous responses on visual pattern recognition, I once saw the following reaction to a Christmas display in a shop window. A West Highland white terrier showed obvious excitement on spotting from about 10 metres distance a model polar bear of similar size to itself.

Answers

Quick quiz #222
Answers

1 Adenosine triphosphate
2 Fast radio burst
3 American standard code for information interchange
4 Bacillus Calmette-Guérin
5 Dichlorodiphenyltrichloroethane

Cryptic crossword #119 *Answers*

ACROSS 1 Diesel, **4** Nimbus, **8** Spit valve, **10** Dot, **11** Easel, **12** Untried, **13** Telephoto lens, **17** Finicky, **19** Signs, **21** Tea, **22** Pheromone, **23** Hobbit, **24** Isopod

DOWN 1 Dissect, **2** Emits, **3** Envelop, **5** Inert, **6** Bedside, **7** Sated, **9** Leukocyte, **14** Linear B, **15** Osseous, **16** Suspend, **17** Fetch, **18** Capri, **20** Group

#241 Escape room

There is no solution to be found here, because we want you to solve puzzle #241 yourselves.

Last week, we asked you to use maths, logic and a dash of creativity to help Prince Golightly escape from a perilous situation. The reward? A copy of *Headscratchers* – our book of *New Scientist* puzzles – will go to the three answers that Rob Eastaway and Brian Hobbs, the book's authors, like best.

For more details about how to enter the competition, go to newscientist.com/puzzles. The winners will be announced in our 28 October issue.

Mapping black holes

Richard Notley has been wondering down a dark path… and found enlightenment in remarks made by mathematician Roger Penrose (*New Scientist*, 19 November 2022) about the structure of the universe. He writes:

"Roger may have solved a problem I have. A continuation of Roman Road, Hereford, on which I live, goes into Black Hole Lane [pictured below]. I have ridden down this lane several times both ways



RICHARD NOTLEY

wondering whether I will hit the event horizon. But I'm still here, so I'm now considering that this should be called 'Naked Singularity Lane' as there isn't an event horizon?"

Richard's isn't the only Black Hole Lane in the UK. Another is Blackhole Lane, a continuation of Derrington Lane in Stafford.

And these British examples aren't the only navigable black holes in the universe. There is also a Blackhole Lane off Witherbee Road in Berkeley County, South Carolina.

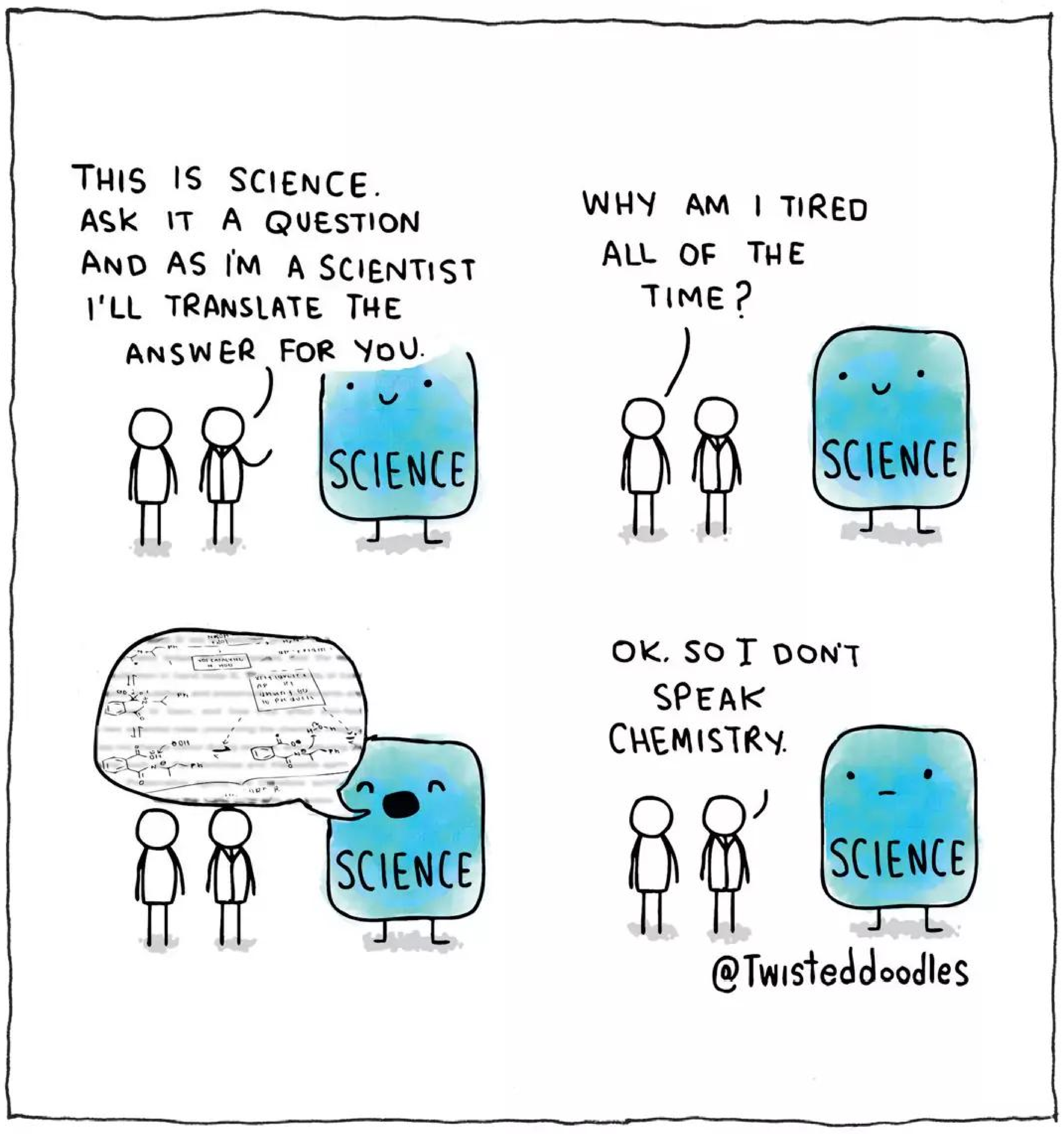
Widening the net, one can find other geographic black holes in North America.

Black Hole Road forks off from Little Valley Access Road near Little Valley in California. And another Black Hole Road branches off Route 31 near Goderich, Canada.

People who use map apps have discovered other Black Hole Roads, too. And in coming years, when more powerful instruments become available to searchers, there might be many additions to the list of known Black Hole Lanes and Black Hole Roads.

More exciting still, given the discoveries of recent decades, who would now rule out the existence of Black Hole Streets, Black Hole Avenues, Black Hole Boulevards and maybe even Black Hole Bridges, Black Hole Tunnels, Black Hole Aqueducts, Black Hole Golf Courses, Black Hole Pubs, Black Hole Hotels, and other black hole locations worth or not worth a visit.

Twisteddoodles *for New Scientist*



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Consideration of items sent in the post will be delayed

Rauks (rocks)

Tom Gill is one of many scientists who always want to know more about the things they love.

"I've been a geology nerd for fifty-plus years," he writes to Feedback. "I was today years old when I learned that a type of rock exists which is officially named… rauks."

Gill's epiphany – that rauks are rocks – came from the city of Wrocław in Poland.

"Clusters of sea stacks, called rauks, are unique rocky landforms characteristic of Baltic Sea coasts," explain Mateusz Strzelecki at the University of Wrocław and his colleagues. The team supplies more detail, and explains how it was acquired, in a study called "Terrestrial laser scanning for the detection of coastal changes along rauk coasts of Gotland, Baltic Sea".

That study adds some geography to their geology report of last year: "Limestone sea stacks (rauks) record past sea levels and rocky coast evolution in the Baltic Sea (Gotland and Fårö islands, Sweden)".

Poland also is, or at least was, home base for a scientist named Jacek Rauk, who in 1969 published a study about the "swelling of roof rocks". Roof rocks are the rocks that make up the top of an underground chamber – such as a mine shaft, a cavern, a lava tube or a gas pocket.

That same year, Maurice Stone at the University of Exeter, UK, co-authored a study about "Determination of lithium oxide in silicate rocks". On the record, 1969 was a good year for Stone and Rauk – and stone and rock.

Worm's view of the tree

Worm, Boris Worm (spoken aloud that way, the name has much the same musical ring as "Bond, James Bond"), has long been a biology professor at Dalhousie University in Canada.

Worm sees humans as predators. You can read his explanation of that in the study "Humanity's diverse predatory niche and its ecological consequences", which Worm and 11 co-authors published in the journal *Communications Biology*.

Back in 2012, many biologists still embraced a relatively simple structure for the metaphorical "tree of life", which is an ongrowing attempt to show how the many kinds of life are related to each other.

That year, Worm teamed up with Trevor Branch at the University of Washington in Seattle to predict what might happen to some parts of the tree that live underwater. Worm and Branch wrote a nominative determinism smorgasbord of a paper called "The future of fish" in the journal *Trends in Ecology and Evolution*. The journal's acronym for itself is TREE.

Following this, lots of biologists were embracing a "dramatically expanded version" of the tree metaphor. The grasping was exemplified by Laura Hug, then at the University of California, Berkeley, and her colleagues writing a paper in 2016 titled "A new view of the tree of life". They said that "even an approximation of the full scale of the tree has remained elusive".

Some efforts to know and protect the tree of life are quite down to earth, none more flatly (and also more blatantly British) than a recent analysis by Joseph Bull, Henry Grub and colleagues, in the journal *Nature*, of "The biodiversity footprint of the University of Oxford".

Marc Abrahams

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